

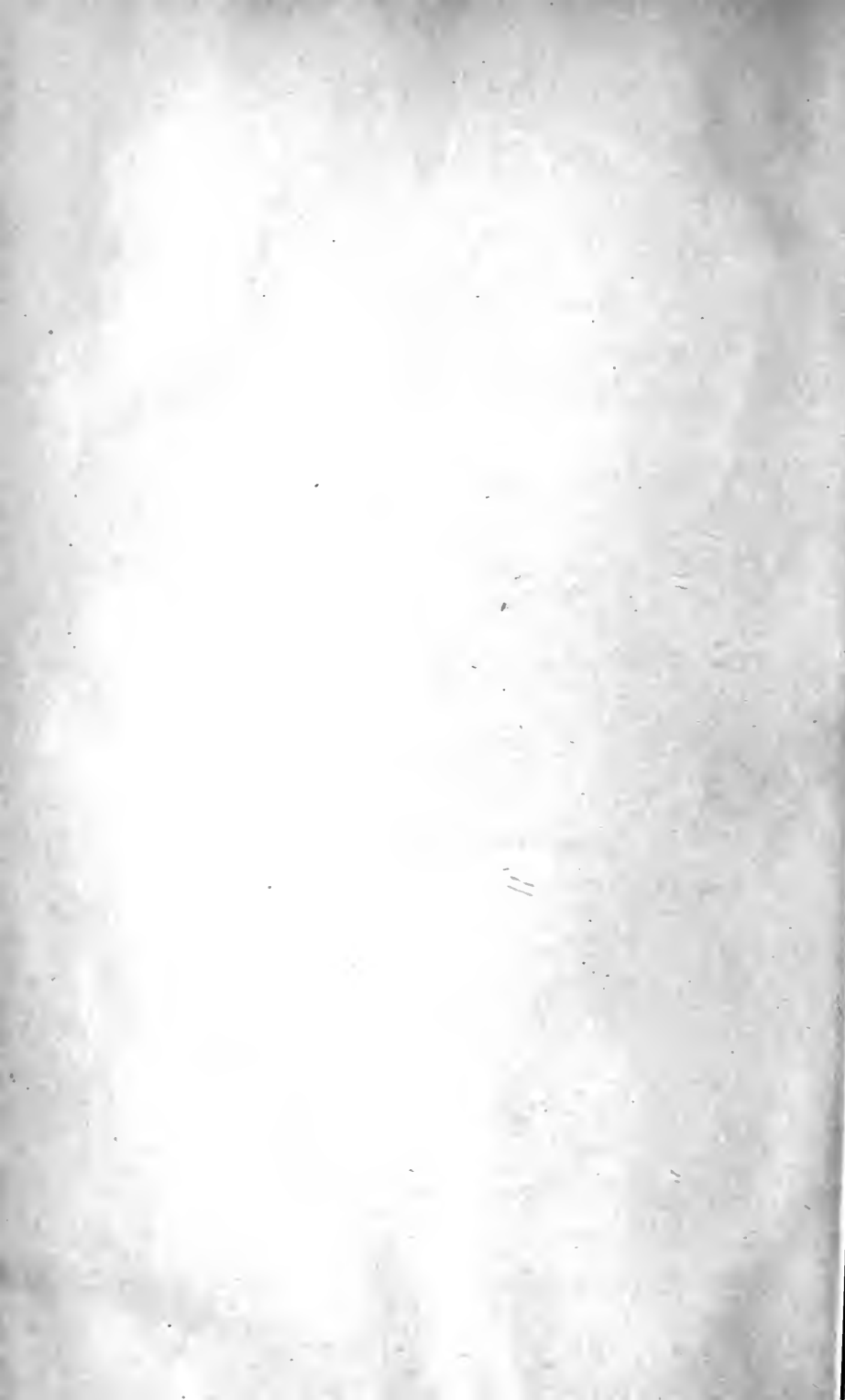


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# JOURNAL

OF THE

## FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE PROMOTION OF THE MECHANIC ARTS.

DEVOTED TO

MECHANICAL AND PHYSICAL SCIENCE,

Civil Engineering, the Arts and Manufactures.

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EDITED BY

PROF. JOHN F. FRAZER,

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JANUARY, 1863.

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#### CIVIL ENGINEERING.

For the Journal of the Franklin Institute.

*Papers on Hydraulic Engineering.* By SAMUEL McELROY, C. E.

PUMPING ENGINES No. 3. (Continued.)

(Continued from Vol. xlv, p. 373.)

**ENGINES.**—The engines, as the second subdivision of our subject, may be specified in two general classes; the *single-acting*, or those which take steam in one direction for each double stroke, being returned by a counterweight; and the *double-acting*, or those which take steam in both directions.

Single-acting engines have vertical cylinders with the pumps beneath them, or beams, with the pumps under the outer end centres, the latter being the rule, the former, the exception.

Double-acting engines may be vertical, inclined, or horizontal, with direct or with crank motions. Direct double-acting engines operate with and without beams (or half beams), the latter being the exceptions, and double-acting crank engines, operate with and without beams, the latter being the exceptions.

*Single-acting Engines.*—In the single-acting mining engines, with beams, the steam stroke makes the suction lift of the several plunger pumps attached to the pump-shaft, and the suction and force lift of the lower bucket pump, the chief pumping stroke being made with the steam piston *in equilibrio*, by the weight of the descending pump shaft and attachments. In the water works engines, but one plunger

pump is generally used, attached to a counterweight, the downward steam stroke making the suction lift. In the "Bull" engines, or those which act without beams, the steam stroke is upward, and also makes the suction lift. But in the Haarlem Meer single-acting beam engines with annular cylinders, the counterweight is lifted on the full steam stroke, the pumping lift being made on the return expansion stroke. These engines are therefore double-acting as to the cylinders in one sense, though entirely single-acting as to the several pumps, and as to distinct piston motion.

The engines of this general class, from their prominent rank, require somewhat particular notice, in which those used at the mines will illustrate the leading principles of operation, the water works engines being modifications of the same type. This notice will include their introduction, general and detail arrangement, and performance.

*Introduction.*—Watt erected his first engine in Cornwall, as an improvement on the engines of Smeaton, Hornblower, Newcomen, and Savery; about 1776, the first steam mining engine having been built about 1713. His prominent improvements included the condenser and air-pump, the expansion gear, the parallel motion, and the steam-jacket, with an improved workmanship and arrangement of details and arrangement of boilers, and have not been much modified since his day. About 1835, Thomas Wicksteed, Esq., Engineer of the East London Water Works Co., advocated the use of the Cornish Engine, and in 1837 the engine at the East Cornwall mines, near Callington, was taken down, altered, and re-erected at Old Ford for the Company. This was the first application of the single-acting beam engine to water works, an example extensively followed since that time. About 1790 several "Bull" engines were introduced in Cornwall, in which the cylinders were placed directly over the pump shafts.

*General Arrangement.*—In general, the boilers are placed in a separate house, connected with the engine house wall, and at a level below the cylinder base, for convenience in coal delivery, in taking steam, and working the steam jacket. The cylinder is housed in from the beam-centre, of which the supporting wall sustains the main pillow blocks, the air pump, condenser, and pump shaft being uncovered. In making the steam stroke, the engine is therefore said to "go in the house," in mining parlance. The cylinder foundation of solid stone work is built up several feet above the ordinary grade. The side pipes and valve gear are placed between the cylinder and main centre so as to be worked by a plug rod from the beam. Great care is taken to enclose the steam pipes and cylinder with various devices to prevent radiation and condensation.

The peculiarities of the *cylinder* are the precautions for maintaining its heat by the steam-jacket, and by air spaces, brick-work, plastering, and lagging, in part or wholly used in addition. The steam-jacket is supplied by a special steam-pipe, and returns its condensed water to the boilers by gravitation. Its chief value is to prevent radiation and to compensate the effects of sudden changes of temperature from those of pressure in expanding, and the continued use of full steam at

the upper end only; for low grades of expansion its value is less apparent. The cover is made double and filled in with some non-conductor; the bottom also is double and supplied with steam, a practice which in the latter case is held objectionable in some instances from its effect on the exhaust. The stuffing-box has a steam packing chamber fed from the jacket to prevent the admission of air during the minus pressure in the cylinder at certain parts of the stroke, an ingenious and important arrangement. The piston-rod is so attached to the cross-head as to be free from it in one direction, in case the steam stroke from any accidental cause should charge the weighted beam with extraordinary momentum, which the spring beams might fail to sustain. These beams are placed above the cylinder so as to terminate the stroke in either direction when the piston does not itself come to its usual rest, catch-pins being placed on the beam for this purpose; a precaution of this kind is advisable, since the end centres or termini of the stroke, are not controlled by a crank; but these engines admit so delicate an adjustment in operation, that the spring beams are safeguards rather than indispensable working parts to each stroke.

The *beam* is generally cast in two plates, bolted together with stud-blocks. Parallel rods are used for guides. It is generally centred so as to reduce the pump velocity in the ratio of 10 (piston) to 8 (pump). The improvements in forging and an assumption of increased safety, have induced the introduction of wrought iron beams, but in this case the large excess of weight used in these beams is overlooked, an excess of great consequence in engine inertia and momentum, which cannot be properly dispensed with.

The *valve motion* is controlled by a single or double plug-rod, from the beam, which is provided with tappets to operate the valve levers, and the cataract lever. The cataract is a very simple and beautiful arrangement by which a small weighted pump plunger, when lifted by the rod, is regulated in its time of descent by throttling its discharge orifice, and opens the exhaust and steam valves for the return stroke by means of certain rods, levers, and cams, at a given point, thereby determining the number of strokes in a given time. This motion, as a whole, is effective and easily adjustable, but somewhat cumbrous and noisy, and is necessarily automatic, from the absence of eccentrics and rotary motions.

Four valves are used, all of which are of the double-beat or balanced form, viz: the governor valve which throttles the admission of steam to the steam chest, and works close to the steam-valve so as to prevent any material collection of steam at full pressure, between them; the steam-valve, which operates in the usual way; the exhaust valve, which opens in advance of the steam-valve at the base of the cylinder; and the equilibrium valve, which provides for the counter-weight return stroke by connecting the lower side of the piston with the upper, so as to produce a balance of pressure. The lap and lead given this valve at will regulates the amount of cushion for the upper and lower piston stroke.

The double beat valve was introduced by Hornblower about 1800, and exerts an essential influence on the operation of the valve gear. The proportions of the steam and exhaust valves are also of great consequence, the former being made about one-fifth and the latter about one-fourth of the cylinder diameter, the pipes being suitably enlarged.

The *condenser and air-pump* are about equal in size, the latter having half the engine stroke, and nearly half the cylinder bore. With its connexions the condenser is about one-third the cylinder contents. In working, the injection is intermittent, being let on and closed with the exhaust, and the "hark" or pause between each stroke is claimed as an advantage to the vacuum. The air-pump, in addition to its foot-valve, has a floating cover as a delivery valve.

The *counterweight* is represented in these engines by the pump-rods and attachments which frequently have inclined lines of motion, and by the use of balance beams and bobs. A weight equivalent to the main pump load and all its frictions is, therefore, put in motion on the steam stroke, as the agent of the return stroke, as is also the case in the Bull engines, and in a less complicated manner in the water works engines. This stroke is therefore controlled and assisted by the inertia and momentum of these weights of the suction columns, and of the lower lift, (noticed under the appropriate head.)

In general arrangement, then, the salient points of the single-acting engine are found in its guards against radiation, condensation, and leakage; its simple and direct motions which reduce friction; its large valve openings, balanced valves, and automatic valve-gear; its condensing apparatus; its weight in motion; and its careful workmanship.

*Performance.*—In operation the engine has these characteristics, —that all its motions are natural and deliberate, harmonizing with its work, both on the steam and equilibrium stroke; that the upper steam cushion is not wasted in power; that high initial pressure and moderate throttling is used, since the inertia of the mass to be overcome, and the time for transmission of impulse freely permit such initial force; that the subsequent *vis viva* of this mass, admits and requires a high range of expansion to prevent waste of power and concussions at the stroke-end; it is also, claimed as an advantage that the piston is independent of the pump column, and does not control its speed, although the experience of the Huelgoat, Haarlem Meer, Brooklyn, and other engines does not substantiate the claim, as a beneficial principle of action. In performance these engines, in use so many years and in large numbers, and of very large sizes, take rank of all others in mining and water works on record. While their average duty is itself far in advance of that of other classes, individual cases range up to a formidable proportion, as we shall have occasion to show in the proper place.

A reference to the single-acting engine is important not only from its rank among pumping engines, but from its position in relation to all other steam engines. The successful development of its principles



of action, underlies all others, and it is impossible to analyze one class independently of the other. The history of the Cornish engine is the history of the steam engine, however varied in arrangement, and one must be diligently studied to comprehend the various divisions of the other, since both are controlled by the same laws of maximum useful effect. This engine is then the true standard, as it is the pioneer also, of all others.

And from this basis of examination it is an interesting study to trace out the various ways in which these several principles of action, are vindicated amid seeming mechanical contradictions. Nothing apparently could be more dissimilar from this standard than a Mississippi engine coughing out steam at 180 and 200 pounds pressure, with its rude expansion gear, and yet it was in Cornwall that the economy of high steam was asserted and demonstrated through numerous trials, as well as the economy of expansion; if then, in Cornwall, it was shown that for a given range of pressure the condenser was an economy, the western waters have continued the demonstration of economy in connexion with convenience by increase of pressure, and rejection of the condenser, simply showing a point where the advantages of condensation may be superseded by increased advantage in manufacture of steam and questions of space. It may be held that the ordinary crank and fly-wheel engine is of a different class, but it agrees as to the admitted use of non-conductors, of balanced valves, of high pressure and expansion, of condensation, of weight in motion, differing chiefly in the arbitrary control of the piston exercised by the crank in reducing a certain reciprocating to rotary motion, and in the detail of valve-motion. Between the counterweight and the fly-wheel there is no difference in principle of action, as each has its distinct work to perform for each stroke. Certain necessities of application require a departure from the simple Cornish motion in various ways, as in combined and horizontal and geared rotary engines, &c., but the standard is never left without a loss in effect. In matters of detail the arrangement of vertical beam engines, the Americanism of balanced puppet valves, the parallel motions, floating air pump covers, boiler feed pumps, injection stands, piston form and packing, and other parts in common practice with us, may be traced directly back to these past generations of experimental research, which in some particulars of this kind may yet be studied and copied with advantage.

That diversity of mechanical form may be consistent with mechanical principle, or in other words, that principles are superior to forms adapted to them, is also, a matter of interesting research. The principle of non-conductors around steam vessels, does not necessarily involve the use of steam jackets, if by superheating or perfect clothing, the same useful effects may be obtained, and some inherent mechanical objections avoided; nor is the use of such devices peculiar to the single-acting engines which introduced them. This is true also, of perfect valve arrangement, and proportion of condenser and air-pump; of pressure and expansion; of inertia and *vis viva*, which may be equally useful and effective in double-acting engines. The supre-

macy of principle being recognised, the subordinate questions of application become special and local, and what is chiefly important is, that principle should always take rank of detail.

The history of the Cornish engine is important in another respect, viz: in the examples it presents of various experimental devices, as modifications or assumed improvements of this standard. The Bull engine was an attempt at increased simplicity in one respect and to avoid a patent in another; it fails however, from its imperfect application of the *vis viva*, and its consequent defects in taking steam and expansion. Hornblower, Wolfe, and Simms in their school, attempting an improvement in the method of expansion and steam travel by combined full steam and expansion cylinders, in which the pressures sometimes were varied as high as twenty to one, overlooked the law of inertia and *vis viva*, and encountered counteractions and serious frictional losses; so also, in the Boulton and Watt, and the various other forms of engines offered as substitutes, a formidable chapter of experiment demonstrates the value of correct, harmonious principle, for the instruction of all who choose to heed it.

*Double-Acting Engines.*—But engineers who comprehend and respect this supremacy of natural law, have also been impressed with the advantages which result from its application to double-acting pumping engines. The single-acting cylinder is open to these objections, as compared with the other,—that it must be not less than twice the size requisite for the same work in its proportions and appurtenances; that the beam and its bearings must sustain not less than twice the load; that the risks and effects of accidents, and the frictions are proportionally increased; that the air-chamber and some other parts must be doubly larger and stronger; that the outlay in capital is much greater, and in annual expense, also, to a certain extent; that the momentum of a weighted and balanced beam is preferable to that of a counterweighted beam, as to losses in excess of initial pressure and adjustments; that the *vis viva* of the force-lift pump column is lost to the steam stroke; and that the elastic steam stroke is better adapted for pumping than the non-elastic counterweight, and produces a better result with much higher and more controllable speed. And it has been reserved for an American engine, which ranks all other pumping engines in actual power, to demonstrate the correctness of adaptations of principle to this modification of form.

If, however, we examine the pumping engines of this country, which are double-acting as a class, in view of the principles enunciated, we find them at fault in several particulars. And first, in their general arrangement, as to the use of the crank.

*Crank Motion.*—It must be admitted without much study, that no change can be made from a reciprocal to a rotary motion, without doing violence to the conditions of motion, and it is also evident from a simple analysis, that the natural movement of a steam piston is inconsistent with the uniform revolution of a wheel or crank, on account of the relative spaces passed in a given time, and the relative variations of pressure and resistance due to each. We refer now to fric-

tional and counteractive losses of power and not to the fallacy of any inherent loss of pressure.

In the elaborate theoretical demonstrations of crank motion which have been made from time to time, it will be observed that the element of mass in motion is neglected, but what is proper for a certain analytical purpose is not to be assumed correct for an investigation of useful effect, since such an element is indispensable to all engines in greater or less proportions. What, then, we have by pump cards, shown to be true of a mobile liquid, in its laws of initial and final motion, certainly cannot be less true of any homogeneous mass of metal, or of the working parts and load of any crank engine; and it is inevitable that there must be a certain initial and surplus impulse imparted to the mass which is felt throughout the stroke, and is compensated by its *vis viva*. After the time occupied in charging the load with this impulse, and from the time the impulse is properly communicated and has produced a maximum velocity, the natural law of piston motion involves a gradual reduction of speed. But the tendency of the crank and fly-wheel is towards uniform speed, and if this could be attained in practice, the piston would vary in speed in a manner entirely incompatible with its legitimate impulse or travel, being retarded where it ought to accelerate, and accelerated where it ought not to be. Hence result severe counteractions and frictions, which tend to reduce useful effect and embarrass proper operation. On one of the most carefully constructed crank engines, we have ever seen tested as to this loss, 23 per cent. was the lowest rate, as compared with the ordinary Cornish result of 10 per cent. and the Brooklyn engine of 7.4 per cent., while in the ordinary cases in practice, the loss easily reaches a much more serious effect from differences in workmanship. We may take it for granted then, that the use of the crank is to be avoided in all cases where the work permits it, and particularly in all pumping engines, from its arbitrary control of natural piston and pump motion without any compensating benefit. The idea that the terminal stroke and valve-motion may not be fully controlled without it is a mechanical error.

*Radiation.*—The general neglect of non-conducting protections for the cylinder and steam-pipes, has an injurious effect on engine duty. While a somewhat quixotic stress has been occasionally laid on cylinder condensation, without corresponding stress on radiation and their preventives, the lessons of correct practice require the proper application of the latter in the most simple and effective way. As to steam-jackets, we believe the Brooklyn engines are the only double-acting pumping engines in the country which use them, and as to the more ready application of felting, and other covering, there is a manifest room for improvement, which will quickly vindicate its value in useful effect.

*Valves.*—The use of balanced puppet valves is correct in principle, while slide valves are generally objectionable, from restricted openings, and increased valve load; nor can the importance of large openings be too strongly urged. Even with locomotive cylinders,

which are necessarily small and used under high pressure, the best practice requires an opening of the full diameter of the piston, and what is true in principle in such a case, is equally applicable to larger cylinders under much less pressure. The severe losses in back-pressure to all cylinders are generally due to restricted exhaust. The losses of steam in the chests and clearance are frequently formidable, and deserve a careful attention. Those engine builders who bring their valves as close as possible to the cylinder ports, find by experience a benefit which is of great consequence. One important reason why long stroke engines are more economical and effective than the short stroke, is explained by the less frequent change of centres and corresponding savings in the clearance and steam chest. As to the working parts of the valve motion, it is a matter of little consequence to the cylinder how they are arranged, and they should be as simple and convenient as possible; "lap" and "lead" are of much greater consequence, and should be carefully adjusted by reference to indicator cards to the maximum effect. There are numerous varieties of expansion gear in use, which illustrate the difference between ingenuity and judgment, and are of unimportant choice, so that the steam-valve shuts at the proper moment, and its time of closing is adjustable conveniently.

*Condensation.*—The relative location, size, and arrangement of the condenser and air-pump, exert an important influence on their office. The vacuum formed by condensation is more or less imperfect from the percentage of air in the injection water, from uncondensed vapor, and imperceptible leakages; the friction of the exhaust passage may also increase back pressure; and a neglect of proportion in the air-pump may add a useless load to the engine, counteractive of effect. These parts should therefore be carefully adapted to their actual work, in proportion and workmanship, with regard to the precise office of each.

*Problem of Useful Effect.*—In pumping-engines which are built to perform certain known work, and in which capacity is determined by size and speed, the problem of maximum useful effect may be adjusted from the pressure, expansion, and momentum, forming the important triad which controls it.

*High Steam.*—As to the manufacture of steam, it is a matter of simple demonstration, which may be omitted here, that it is cheaper to make it in a ratio progressive with its pressure, from the law of pressure and density, the standards of boiler radiation and other losses, the increased absorption of heat by water, and other natural and mechanical causes; but in ordinary boiler practice, and particularly in condensing engines, there is a limit to pressure, which seems to be established by common consent, considerably below 100 pounds, (plus pressure.) In fact, the Cornish practice, from 45 to 75 pounds, is considered high in our pumping practice, and is erroneously rejected, except in the Western high pressure non-condensing engines. There can be no question of the superior economy of the Cornish process, which indicates a lesson to be followed in that respect.

*Momentum.*—With a given average pressure to provide for a given load, and proper initial pressure, which should not be throttled if it can be avoided, (although in badly proportioned engines throttling is much better than low boiler pressure,) the ratio of expansion acting in connexion with the weight to be put in motion, assumes its proper rank in this problem of effect. Though it is manifest that the same average pressure will balance the same average load, and initial pressure and expansion might therefore be indefinitely increased with increasing gain, the conditions of momentum place a limit to this ratio, and indicate its range of practical usefulness.

*Expansion.*—The doctrine of maximum effect, depending as it does under these conditions, on engine momentum and expansion, makes it clear that either may be regulated so as to control or facilitate the other, and that the engine mass should be so adjusted, within reasonable limits, as to permit a suitable measure of expansion. To say that an engine works imperfectly from being too light, or to say that engine weight in motion is the true measure of its economy, involves a very deep and important meaning, which theory has demonstrated and practice confirmed for generations, although it is not often put in type. The *rationale* is not complicated;—it is necessary to obtain a given initial impulse in excess of the average resistance, that the moving parts and load should have sufficient inertia to prevent abrupt motion; this inertia, in fact, regulates the range of initial pressure, and when overcome by it, and a certain speed generated, the moment for cutting off is reached, and the reducing piston pressure is compensated by the generated *vis viva*, these jointly completing the stroke. The idea of uniform resistance or uniform pressure on any steam piston, is a mechanical myth, existing only in the abstruse regions of speculation; and in every case where an engine will not take steam without close throttling, or will not cut off short, it may be taken for granted that its proportions are at fault in this respect.

As to the usefulness of expansion, *per se*, which has been called in question, under circumstances amply discussed in former pages of this Journal, it may be said that if no other experience existed than that which the Cornish engine has put on record as to this particular, aside from the testimony of natural laws, and as a mere result in reducing annual expense, the correctness and propriety of its use, up to one-twentieth cut-off, is established beyond peradventure. In scores, and fifties, and hundreds, by tens, twenties, and fifties of years, the mining engines alone furnish proof enough on this subject, to establish a theory against all doubts, and all contradictory demonstrations. Cases of this kind furnish proof of the argument advanced in the outset, that the lessons of the past cannot be safely overlooked or neglected by the present, and that principles always vindicate themselves to the benefit or the cost of humanity.

*Combined and Geared Engines.*—Having briefly sketched the salient points of single and double acting engines, and their movements, in reference to leading principles, some allusion is due to the

practice which obtains with the latter class, in some cases, of combined movements and transmitted power.

What has been shown in reference to combined pumps on the same force main, as a source of injurious counteractions, is equally applicable in spirit to any attempt to make two or more steam cylinders work exactly in harmony, when coupled to the same shaft or working parts of any kind. So long as resistances, in a steam engine, mainly determine pressure, it is impossible that two or more cylinders, taking steam at different times, and offering different pressures at the same time to a common resistance, should avoid mutual counteractions; one must alternately drag and carry the other, to an extent measured by the condition of each special application; each, in turn, must do more than its proper proportion of the work; and combined cylinders at sea and in locomotives, were introduced for the purpose (among others, of convenience in arrangement, &c.) of keeping the engine off its crank-centre; an idea experience has sufficiently corrected aboard ship, and would also correct on the railway if tested. In all cases of combined cylinders, the power to be exerted by each, must be in excess of its due proportion to the legitimate aggregate work. Beside this plain principle of alternate action, in cases where no attempt is made to develop uniform power, the subdivision of engine work into several cylinders, involves a large increase of loss by clearances, leakage, radiation, friction of piston, valve gear, and other working parts, for no good reason whatever, in the attempt at uniform pumping speed, which is itself a demonstrated fallacy.

Without pausing here to specify cases in illustration, as we are now discussing generalities rather than details, it may be said in reference to all geared engines, and other means of power-transmission between the steam and pump pistons, which depart from the simple arrangement of the Cornish engine, that they are defective precisely in the ratio of increased frictional resistance incurred in each special case, as also in quietness of action and other particulars.

And of this point in general it may be asserted, that as an attempt to alter the pumping motions of the standard engine, or to obtain double action at the expense of power, or to modify in any respect the salient features of the master type, for unimportant or subordinate conveniences, they are evidently open to serious objection, and prove it in their records of duty.

*Summary.*—Taking the single-acting engine as the standard of example and comparison, from its rank as to age, arrangement, and performance, in such manner as an article of this kind will permit, we have endeavored to present as a matter of principle for universal application, and independent of special and local demands, those peculiarities of its operation which seem to be most worthy of general adoption, and are defined by protection from power-waste, directness of motion, perfection of detail and workmanship, pressure, expansion, inertia, and condensation. The several points involved in this group of characteristics have been so presented in contrast or connexion with our diversified school of engines, and with double-acting

engines generally, as to furnish some pertinent basis of judgment on their merits in special cases, under the light of general rules.

Keeping the chapter of engines distinct from that of pumps, we have also avoided here any discussion of special illustrative examples, since the application may be easily made to each or all, and is not immediately involved under this investigation. In some future remarks on engine duty, special applications may be more properly made.

It may be also said, that the low standard of results in some examples of the Cornish school, are simply proofs of their failure, in some respect or other, in proper development of their inherent principles of action, and may be properly charged to incorrect design, construction, or management. This is a case where principles must be held independent of individual results, by which they are negatively vindicated.

(To be Continued.)

### *On the Preservation of Stone.*

From the Lond. Civ. Eng. and Arch. Jour., Sept., 1862.

In our fourth article on this important subject, we proceed to give, as promised, a digest of the process of Messrs. Bartlett Brothers, Camden Town, for the induration and preservation of stone; first however giving an analysis of the latest patent that has passed the Great Seal having the same object in view. This patent has been taken out by Mr. Herbert Church, and is to a great extent based upon the late discovery of Professor Graham, that of obtaining an *aqueous* solution of silica. We pay all deference to the discovery of such an important chemical fact, and feel deeply interested in the results; but, so far as we are able to judge, the solution is wrongly applied in this particular instance. The materials proposed to be used by Mr. Church are an aqueous solution of silica, or an acid solution of silica, and caustic baryta. Beginning, then, with the aqueous solution of silica, let us mention a few of its peculiarities, and then leave our readers to judge how far it is available for such uses as that we are descanting upon, in a commercial point of view. The primary disqualifications are—1st. That it cannot be retained long in solution, but gelatinizes in a comparatively short space of time. 2d. Any agitation by transit or otherwise at once produces this thickening of the solution; so that in either case, from either cause, it is rendered inutile for any purpose where penetration is essentially necessary. None other than a comparatively limpid and true solution can enter the pores of a stone for any purpose whatever. As to the cost of the solution made by the agency of the dialyzer, it must be considerable, and we cannot yet see how it can be produced at commercial prices, for surely no cost of induration should exceed the difference in price between a soft stone, and one that is hard and possessing the maximum degree of durability.

Before leaving the aqueous solution of silica, we would ask, where-

fore should the potash be withdrawn, when in this alkali we have a valuable adjunct for all combinations with other bases? Let us illustrate our assertion by a well-known fact in nature's operations. Felspar is a compound of silica, potash, and alumina, and forms one of the constituents of our standard of durability, granite, and it requires the action of centuries to reduce this felspar to an inferior condition, yet is this at last accomplished by the removal, by atmospheric influence, of the potash. Hence, may we not infer that the presence of the potash is absolutely necessary? Of course, with that which is over and above the correct equivalent we have not been dealing; but even a slight excess is a matter that requires due consideration, before we could pronounce it in the least degree harmful to the stone. In some stones, indeed, we are prepared to say it certainly is not; and in our last article on this subject we find Messrs. Coombe and Wright providing, by the use of silicate of potash, for any deficiency in the stone of this material; and not only in felspar, but also in the mica of the plutonic rocks do we find a large percentage, of potash, as the following analysis will show:

FELSPAR.		MICA.	
Silica,	63.74	Silica,	53.75
Alumina,	17.14	Alumina,	24.62
Lime,	3.00	Potash,	21.35
Potash,	13.06	Loss	00.28
Water and loss,	3.06		
	100.00		100.00

Having thus proved the durability of these silicates of alumina to be dependent to a large extent upon the presence of potash, we naturally deduce that the total removal of the potash is a disqualification and hindrance to the combination of the silica with another base.

The second solution proposed is an acid solution of silica; in fact, the very solution from which the former one would be separated by the dialyzer. This solution is made from a silicate of soda or potash neutralized by an acid—say hydrochloric—and is, as the inventor specifies, made decidedly acid. We cannot see any advantage in this solution over the fluo-silica acid, except in price; plainly all the disadvantages of an acid action are there present, and these we have already enumerated when dealing with the fluo-silicic acid process of Messrs. Coombe and Wright. We then come to the baryta; this, says the patentee, must be caustic baryta, used by preference of a temperature as nearly as conveniently to boiling heat. We cannot attempt to remove the prejudices that will at once present themselves against such a caustic solution. Touching the commercial part of the matter, we must however say, that (as fairly acknowledged by the patentee) on the least exposure to the air, it becomes covered with a pellicule of carbonate material; and we might also ask, what substitute for brushes is to be found for manipulation, as all known kinds would, in a few hours, be reduced to a rotten pulp?

Here however we leave the materials: and now for their application



and combination. The patentee purposes, by the application of two solutions separately applied, to produce a mutual decomposition in the pores of the stone of the materials so applied; thus silicate of baryta is said to be deposited. The insuperable objection to the use of two solutions has always been the uncertainty of the proportion in which the separate solutions shall be presented to each other in the stone, and the difficulties arising from the liquid passing that which is already decomposed on the face of the stone to the interior. These difficulties have, to our mind, been always insurmountable; and the patentee seems to have his doubts, when he speaks of the use of vacuo and atmospheric pressure to effect the entrance to a desirable degree of the solutions into the stone. We cannot but look on this patent as identical with that of Mr. F. Ransome, and this is another instance in which we have to advert to the difficulty of obtaining valid and secure patents under the existing state of the patent law, and the necessity that exists for patentees to be well advised in this matter. Were either of these patents worth litigation, we plainly foresee that litigation would take place, to the vexation and damage more or less of both inventors engaged.

Respecting the process of induration by silicate of alumina, referred to in the commencement of this notice, this substance appears to fulfil to an extraordinary extent the requirements that past experience in the matter have shown to be necessary. Silica has ever been known to possess a great affinity for alumina, especially in the presence of an alkali. Fuchs says, "alumina combines with silica to form an insoluble product; thus in the manufacture of water-glass, the quartz should not contain any alumina, and the *insoluble* residue left behind when the mass is dissolved in water is probably owing to the alumina which the glass has taken up from the glass pot." In the same pamphlet by Fuchs we read, "If for instance a burned plate of potters clay, which possesses no particular hardness, and can be easily broken in pieces, is saturated with moderately concentrated water-glass; and if the soaking be repeated when it has become dry, it is rendered so hard that it resists both chemical and mechanical action which is made to bear upon it." Here, then, we have the highest and most incontestible evidence of the affinity of alumina for silica and its enduring results, as far as insolubility is concerned; and looking at the constituents of granite, as given in the analysis of its mica and felspar, we find this enduring material to consist chiefly of silica and alumina, and almost wholly of silica, alumina, and potash; and by a parity of reasoning, a process that will secure the impregnation of stone by these substances, seems to leave little to be desired, so far as its materials are concerned. In the case of a siliceous stone, where lime is altogether absent, we should have an artificial mica deposited in the stone; and where lime is present it would be found entering into combination, and without doubt producing an artificial felspar. The completeness of this process has been already remarked upon; for if the before-mentioned elements did not admit of manipulation in a perfect manner, the whole system would prove but a beautiful theory,

not reducible to practice. An extract from the "Annales des Ponts et Chaussées" will show how far we are corroborated by M. Kuhlmann in our statement, who had already theorized in the matter. Failing in success with the silicate of potash or water-glass *seulement*, he tried hydro-fluo-silicic acid; and then advancing another step, the "Annales" state "lastly, he has obtained excellent results from the fixation of potash in the soft limestones by substituting aluminate of potash for the hydro-fluo-silicic acid, the employment of which he has advocated with a view of forming in the stone a compound *analogous* to mica. He thus replaces mica by felspar, which likewise fixes potash in a state of insolubility. From this also he concludes, that in calcareous stones the presence of alumina alone may explain the fixation of a certain proportion of potash, and ought to remove every fear of any alteration in silicified limestone by the slow action of time."

Now here we undoubtedly have the theory of forming an artificial mica or felspar in the stone by the use of successive applications of silicate of potash and aluminate of potash; but as M. Kuhlmann from that date (1858) to the present time has not carried this system into practice, we deduce, as well as from our own experience, that in practice the application of two solutions in a separate form failed in practical working. To Messrs. Bartlett Brothers, then, are we indebted for the completion of the theoretical systems of both Fuchs and Kuhlmann, inasmuch as they have discovered that in an alkaline menstruum the silica and alumina may be used (with proper limits as to time) as one solution; thus, wherever the one is conveyed the other is present in its due proportion, leaving nothing to chance either concerning the presence of the re-agent or its due proportion. If then saturation of a porous body with the elements of mica or felspar, for which element it has a great affinity, adds to it hardness, durability, and consequent resistance of the injurious effect of time and atmosphere, certainly that is effected in Messrs. Bartlett's process; and whilst we may look upon the "honorable mention" of the jury of Class II. as confirmatory of this opinion, we cannot see why their approbation should have stopped short of the award of a medal for the untiring perseverance and energy that has developed so satisfactory a solution of this important question.

### *The Economic Construction of Girders.\**

From the Lond. Civ. Eng. and Arch. Jour., Aug., 1862.

(Continued from vol. xlv. page 384.)

*Girders of Great Span.*—The most striking peculiarity of a girder of very great span is, that a large portion of its strength is absorbed in supporting its own weight: and were the span extended to a certain point (varying, however, according to the economic merit of its

\* Some errors in our last paper were unavoidably left uncorrected. The more important are, page 193, col. 2, line 40, for  $\epsilon$  read  $\epsilon:1$ ;† Page 194, col. 1, line 26, for  $i''$  read *one inch*; line 36, for  $\frac{1}{S}$  read  $\frac{1}{8}$ ; line

33, the central formula should have come first; col. 2, line 23, for *net* read *ultimate*.

† Jour. Frank. Ins., vol. xlv. p. 314, 8th line from bottom; p. 318, lines 2d and 4th from top; p. 319, line 4th from top.

particular construction and the quality of the material made use of), the girder would just break down from its own weight, and when this point is reached, by no amount of additional material could this ultimate span be extended while the nature of the structure remained unimproved.

Another peculiarity, the importance of which has never, so far as we are aware, been sufficiently enforced on the attention of engineers, is the immense saving of material and expense that is secured in a great girder by adopting a mode of construction which on the small scale would show only a very moderate percentage of economic merit over another. This is one of the points we shall endeavor, in our next paper, to place in a clear light before the reader, and the results will justify our high estimate of the importance of such investigations as those in some of our previous papers, devoted to the discovery of the most economic designs and arrangements of girders.

*The Factors of Safety.*—The first question that demands our attention is the proportion which the absolute strength of the structure should bear to the greatest possible stress that may be brought upon it in actual work; or, in other words, the proportion that should exist between the ultimate and working stresses. Great diversity of opinion has been shown upon this point by engineers, but we need not encumber our pages with criticising the ill-judged extremes that have been by some adopted. With regard to the factor of safety for dead weight or still loading, we may almost assume it as a settled matter, that in wrought-iron structures the absolute strength should be about, but not less than, *three* times that which would just withstand the stresses; or, in other words, that the factor of safety should be about 3, not less, and not much more.

It is as to the strength to be provided to withstand a moving load—such as a railway train—that such diversity of opinion exists. The reasons for augmenting the factor for the movable loading above that for the still loading, are—1st, the direct shocks or blows from the wheels on passing over irregularities in the roadway; 2d, the suddenness with which the load is imposed; and 3d, the reaction when the engine rapidly surmounts any sudden rise in the road near the centre of the bridge. Now it will be at once perceived that each of these prejudicial actions becomes rapidly less significant as the span increases, and for long spans may become in a primary form inappreciable, leaving only a vibration throughout the structure, which will heighten to some degree the destructive power of the still as well as of the movable loading. The *first* of the above mentioned prejudicial actions of a rapidly moving load, viz:—that from direct blows of the wheels, may become somewhat serious in very short and light spans, since in such the load on the falling wheel may constitute an important percentage of the whole mass of loading and structure taken together; but in a long span, with the load supported on a great many wheels, and the structure itself of great weight, the effect of only one or two wheels dealing their blows at the same instant, becomes, when considered with

regard to the whole structure, almost inappreciable. The *second* prejudicial action is likewise deserving of attention in very short spans, since in these the engine may come so suddenly upon the centre of the bridge as to act in some degree the part of an instantaneously imposed load, acquiring a certain downward momentum from the flexure of the bridge; as, however, the load is again removed with equal rapidity, too much importance should not be given to this effect, and for the case of any span of importance it may be said to vanish. The *third* or last detrimental action is also almost confined to very short spans; in long spans it is only a very small fraction of the load that could have its effect thus increased at the same instant.\*

We will now examine the modes of apportioning the ultimate strength or breaking weight of a structure, as proposed by Professor Rankine and Dr. Fairbairn. The latter gentleman, in a paper read before the British Association in 1861, (see vol. for 1861 of this Journal, p. 329,) speaks as follows:—"For the present I would advise that in all beams and girders, tubular or plain, the permanent load, or weight of the girder and its platform, should not in any case exceed one-fourth of the breaking weight; and that the remaining three-fourths should be reserved to resist the rolling load, in the proportion of 6 to 1." Now the results by this rule are given in columns 3 and 4 of Table I., column 4 giving the *general factor*, or that estimated over the whole loading  $W$ , fixed and movable without distinction; and it will be perceived that we have its values arranged in two series, the first a decreasing one, giving a minimum of security when the dead weight becomes double the movable loading; and at this point a new and increasing series begins, which we apprehend could never have been contemplated by Mr. Fairbairn. In the Conway bridge as executed, the dead weight is about three times the greatest movable, and by this table we find the general factor, according to Mr. Fairbairn's rule, to be  $= 3$  for such a case; but had the structure been lighter, say equal to twice the movable loading, Mr. Fairbairn's rule would have given a factor  $= 2.75$ , being less instead of greater than for the heavier structure—this, of course, he could not have intended.

Professor Rankine gives the following factors:—for the fixed load, factor of safety  $= 3$ ; for the movable load, factor of safety  $= 4$  to  $6$ . In the table we have given the results for the general factor, arising from the adoption of values of the latter  $= 6$  and  $4.5$ . It may be pointed out that these factors lead to the same results as though we increased the movable loading to 2 tons and 1.5 tons per foot run respectively, and treated it along with the dead weight.

On comparing the general factors obtained by these methods, particularly for the case of the fixed loading being double the movable, it will be perceived how widely they differ.

\* We must call attention to the fact that the transverse girders to support the roadway are peculiarly liable to all the evils that may arise from the mobility of the loading. It comes with excessive suddenness upon them, and is nearly their whole loading; a blow from a pair of engine driving-wheels is a blow from nearly their whole loading; at the same time their mass is small—a high value should, therefore, be given to the factor of safety for these girders.

TABLE I.

Actual working loadings per foot run of span for a double girder, the movable loading being = one ton per foot run.		Strength required by Dr. Fairbairn's scale.		Strength required by Professor Rankine's method.			
				Factors = 3 and 6.		Factors = 3 and 4.5.	
Dead Weight $W_1$	Total Weight $W$	Breaking Weight per foot run.	General Factor or Breaking Weight $\div W$ .	Breaking Weight per foot run.	General Factor or Breaking Weight $\div W$ .	Breaking Weight per foot run.	General Factor or Breaking Weight $\div W$ .
0.00	1.00	6.00	6.00	6.00	6.00	4.50	4.50
0.25	1.25	6.25	5.00	6.75	5.40	5.20	4.20
0.50	1.50	6.75	4.33	7.50	5.00	6.00	4.00
0.75	1.75	7.00	3.86	8.25	4.71	6.75	3.86
1.00	2.00	7.50	3.50	9.00	4.50	7.50	3.75
1.50	2.50	7.75	3.00	10.50	4.20	9.00	3.60
2.00	3.00	8.00	2.67	12.00	4.00	10.50	3.50
2.50	3.50	10.00	2.86	13.50	3.86	12.00	3.43
3.00	4.00	12.00	3.00	15.00	3.75	13.50	3.38
3.50	4.50	14.00	3.11	16.50	3.67	15.00	3.33
4.00	5.00	16.00	3.20	18.00	3.60	16.50	3.30
6.00	6.00	20.00	3.33	21.00	3.50	19.50	3.25
7.00	7.00	24.00	3.43	24.00	3.43	22.50	3.21
$\infty$	$\infty$	$\infty$	4.00	$\infty$	3.00	$\infty$	3.00

We must object to the results given by Professor Rankine's method, for the reason that the general factor does not diminish at first with sufficient rapidity to represent the rapid diminution in the destructive effects of a train on changing from the shortest and lightest spans to somewhat longer and heavier ones; and for the very long and heavy spans the factor diminishes too markedly. This is the opinion we would be led to on viewing the subject independently of the stresses induced in the booms by the transverse lateral action of the wind, which it has hitherto been the custom to ignore; but when these stresses are allowed for, we apprehend that the general factor may, with sufficient accuracy for a general rule, be taken constant after reaching a certain value, such as 3.5. This assumes that after a certain point, any reduction that might be made in the factor on account of the smaller proportion of the movable compared with the fixed loading in longer spans, will be counteracted by the demand for additional strength on account of the detrimental action of the wind upon the booms. We may assume the width of structure as constant, the stress on the booms from the wind will therefore increase somewhat more rapidly than the square of the span; in long spans, furthermore, that increase in the effect of a blast which arises from the suddenness of its application may become augmented, and there is also an increased chance of the wind impulses corresponding with the oscillations of the structure. The destructive effects of the wind in extreme spans may possibly, therefore, become so great as to

demand a higher allowance than the above assumption affords.\* As a general rule, however, we feel some confidence in recommending a uniform general factor of safety to be applied, without distinction, to fixed and movable loading† for wrought-iron railway-bridges of great spans, according to column 4 in Table II.

TABLE II.

Fixed loading per foot run, the movable loading being = 1 ton. $W_1$	GENERAL FACTORS OF SAFETY ACCORDING TO		
	Dr. Fairbairn.	Professor Rankine (Special factors = 3 and $4\frac{1}{2}$ .)	Mr. Bow.
0.00	6.00	4.50	6.00
0.05	5.76	4.43	5.71
0.10	5.55	4.36	5.45
0.15	5.35	4.30	5.22
0.20	5.17	4.25	5.00
0.25	5.00	4.20	4.80
0.30	4.85	4.15	4.61
0.40	4.57	4.07	4.29
0.50	4.33	4.00	4.00
0.60	4.12	3.94	3.75
0.70	3.94	3.88	3.53
0.80	3.78	3.83	3.50
0.90	3.64	3.79	3.50
1.00	3.50	3.75	3.50
1.25	3.22	3.67	3.50
1.50	3.00	3.60	3.50
1.75	2.82	3.55	3.50
2.00	2.67	3.50	3.50
2.25	2.77	3.46	3.50
2.50	2.86	3.43	3.50
3.00	3.00	3.38	3.50
3.50	3.27	3.33	3.50
4.00	3.33	3.30	3.50
$\infty$	4.00	3.00	3.50

The general factors for moderate spans are estimated by assuming 6 tons per foot run of span as the minimum value to be put upon the breaking weight. The decreasing series of values resulting from this is made to terminate at 3.5 as the lowest allowable factor, this term is reached when the fixed loading amounts to 0.714 ton per foot run, or 71.4 per cent. of the movable.

For really great spans, then, we have the uniform general factor of safety =  $3\frac{1}{2}$ , and for such spans we now proceed to investigate the weights of the girders.

#### THE WEIGHT OF A GIRDER OF GREAT SPAN.

Let  $s$  = the span for calculation, being, when correctly measured, the distance in feet between the centres of pressure on the supports.

\* The relation of the values of  $w_1$ , (the fixed) and  $w_2$  (the movable loading) has of course some influence upon the stresses in the braces, particularly upon the central ones, but for constructive reasons these braces are at any rate made with a great excess of strength, so that practically an increase in  $w_2$ , compared with  $w_1$ , would only necessitate the strengthening of the central diagonal ties to fit them to act more forcibly as struts under an irregular loading; the amount of extra material required would be so minute that we cannot regard it as affecting the above general rule.

† In cases such as the Conway bridge, where we have a large flat surface exposed to the wind along with extreme narrowness of structure to resist it, additional strength must be provided.

Let  $w_1$  = the gross weight of the length  $s$  of the complete structure due to one double girder; that is, the total dead weight borne by the girder or girders which have to carry a movable load =  $s$  tons railway bridges.  $w_1 = w - w_2$ .

Let  $w_2$  = the movable load =  $s$  tons.

Let  $w$  = the whole load supported by a double girder =  $w_1 + w_2$ .

Let  $g$  = weight of the girder suited to carry the load  $w$ , but  $g$  does not include parts not directly required to fit it for supporting the load.  $g = w_1 - F$ .

Let  $F$  = all the fixed loading exclusive of the girder  $g$ ; that is,  $F$  = the weight of cross-girders, planking, horizontal and transverse bracing, hand-railing, permanent way, &c.

$$F = w_1 - g.$$

Prop. I. In any particular form and construction of girder of given span and depth and value of the factor of safety, we may, within practical limits, assume that  $g$  varies as  $w$ .

Prop. II. When  $w$  is constant but  $s$  variable, and the factor and the relation of the depth of girder to the span are constant, we may assume within limits which secure the struts against material weakening, that  $g$  varies as  $s$ . Therefore

Prop. III. In any special form and construction of girder in which  $s +$  the depth  $D$  is constant, and in which the factor and the allowances of metal to the corresponding struts may be made the same,  $g$  varies as  $ws$ .

$$\text{Let therefore } g = ws k \quad . \quad . \quad . \quad (1)$$

$$k = g + ws \quad . \quad . \quad . \quad (2)$$

$k$  being a constant depending upon the value of the factor of safety directly, and inversely upon the economic merit of the structure; we may distinguish the value of  $k$  corresponding with any particular value of the factor by writing that value against it thus,  $k_{3.5}$ ; on this principle  $k_1$  will indicate that the value is taken for the case of a breaking weight.

In formula (1) for  $w$  substitute its equivalent  $w_2 + g + F$ , and we have  $g = sk (w_2 + g + F)$ , whence we obtain

$$g = \frac{skw_2 + F}{s1 - k} \quad . \quad . \quad . \quad (3)$$

Before we can make direct use of this important formula, we must describe the principles on which  $F$  is to be calculated or estimated for different structures; this, however, we must defer till our next paper.

We at once see from the formula that  $g$ , the weight of the girder, becomes infinite when  $sk = 1$ , or  $s = \frac{1}{k}$ , and therefore points out the ultimate span for the particular construction corresponding with  $k$ . Then since  $k$  varies directly with the factor of safety, we see that the ultimate span for a breaking weight  $\left( = \frac{1}{k_1} \right)$  will be  $3\frac{1}{2}$  times larger than that which can be reached without overstepping the stresses we

have been led to consider judicious, (that is the ultimate span under proper stresses  $= 1 + k^{3.5}$ ).

In our paper for next month we propose arriving at expressions for  $F$ , and thereafter deriving values of  $k$  from various structures, and will conclude with a table of the weights of girders of various spans, and constructed on different systems; showing the immense saving that may, and *ought* to be effected in large structures, by attention to the principles we have developed. In the meantime we append an article of some importance and of general application, which we shall require to make use of on resuming the subject of the Economic Construction of Girders of Great Spans.

(To be Continued.)

*On the Value to be taken for the Depth of a Girder when applying the common Formula for its Strength.*

From the Lond. Civ. Eng. and Arch. Journal, August, 1862.

If any girder in which the moments of the web may be neglected on account either of its thinness or openwork character, the stress produced by a uniformly distributed loading ( $=W$ ) is in either of the booms equal to  $WS+SD$ , wherein  $D$  is the depth or distance apart of the booms treated as mere horizontal lines, and  $s$  the acting span. Now in applying this formula in practice, it becomes necessary to assign a value to  $D$  less than the extreme depth of the structure, since the booms are not simple lines, but must have some vertical dimension; and it is only the extreme layer which acts with the full force of  $c$  or  $eT$ ,\* and with full leverage of the extreme distance above or below the neutral axis.

Let  $M_1$  be the sum of the moments of all the fibres of the bottom boom measured round the neutral axis; and  $M_2$  = the sum of the moments of the various parts of the top boom. Now we require to find a point in the cross section of each boom so situated that were *all* the section of the boom acting there with the full force of  $c$  or  $eT$ , the moment (that is the full sectional area of the boom multiplied by the distance of the point from the neutral axis and by  $c$  or  $eT$ ) will be equal to  $M_2$  or  $M_1$ . Let  $A_1$ † be the sectional area of the bottom boom,  $A_2$  that of the top boom,  $D_1$  the distance of this point in the lower boom below the neutral axis, and  $D_2$  the distance of the point in the upper boom above that axis.

Then  $A_1 D_1 eT = M_1$ , and  $A_2 D_2 c = M_2$

$$D_1 = \frac{M_1}{A_1 eT} \text{ and } D_2 = \frac{M_2}{A_2 c} \quad . \quad . \quad . \quad (1)$$

$$D = D_1 + D_2.$$

The ordinary practice of assigning a value to  $D$  equal to the distance between the centres of the sections of the booms is so very far wrong, and liable to lead to such grave errors, that we feel it incum-

\* The symbols here employed are the same as in the papers on "The Economic Construction of Girders."

† The areas and moments of the portions of the web of a plate girder could be readily introduced into the discussion, but such a mode of treatment would annul any advantage from employing the above simple formula for the strength.



bent upon us to enter into some detail, in order to show by examples the great difference between the correct results and those obtained by the usual modes of carrying out the calculation.

For this purpose we may restrict our attention to the parts and their moments on one side of the neutral axis; let it be that of the upper booms.

1st. When the upper boom consists of one or more rectangular cells. Let  $A$  be the area of the upper plates,  $B$  of the lower, and  $x$  of the vertical plates. Let  $h$  be the distance of the centre of  $A$  plates, and  $i$  = the distance of centre of  $B$  plates, from the neutral axis  $n$  in the diagram.

Then by formula (3), page 194 *ante* we have the moments.

$$c = (Ah + B \frac{i^2}{h} + x \frac{1}{3} (h + i + \frac{i^2}{h}))$$

and therefore to obtain  $D_2$  we divide this by the area into  $c$ , *i.e.*, by  $c(A + B + x)$ ,  $\therefore$

$$D_2 = \frac{Ah + B \frac{i^2}{h} + x \frac{1}{3} (h + i + \frac{i^2}{h})}{A + B + x} \quad (2)$$

*Example.*—Let the areas  $A$ ,  $B$ , and  $x$  be taken all equal, and the formula becomes

$$D_2 = \frac{4h + i + 4 \frac{i^2}{h}}{9}$$

by which we get, on assuming different ratios between  $h$  and  $i$ , the results given in Table I.

TABLE I.

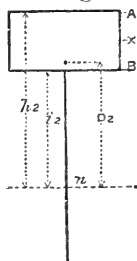
Proportion of $h : i$ .			Values of $D_2$ .		Percentages of Error.
$h$	:	$i$	Correct.	Usual.	
2	:	1	1.222	1.5	22.7
3	:	2	2.148	2.5	16.4
4	:	3	3.111	3.5	12.5
5	:	4	4.089	4.5	10.5
10	:	9	9.044	9.5	5.0

It will be perceived from the table that when  $i$  is not greatly less than  $h$ , the value of  $D_2$  should be very little greater than  $i$ .

We have calculated by formula (2) the correct value of  $D$  for the Conway tubes, using the moments given in the foot-note at page 194 *ante*\*, and find it equal 22.067, the extreme depth outside being 25 ft. 5 in., and the inside depth 21 ft. 7½ in.;  $i$ , or depth between centres of plates  $B$  and  $C = i_1 + i_2 = 21.688$ .

Now this smallness of the value of  $D$  will account in a great measure for the extreme heaviness and weakness of the Conway (and Britannia) tubes, the proportion of span to depth being so great as

\* Jour. Frank. Ins., vol. xliv. page 318.



$\frac{405}{22.067} = 18.35:1$ , or, if we follow the less exact but usual course of taking the clear span, we have  $\frac{S}{D} = 18.13$ .

The correct value of  $D$  for the large experimental tube in Experiment IV. is  $= 4.07$ ; the depth between the centres of the extreme top and bottom plates is  $= 4.53$ , and between the centres of the bottom and lower top plates is  $= 4.015$ . And the value of  $\frac{S}{D}$  is  $= \frac{75}{4.07} = 18.43$ .

As many readers may feel surprised at the true value of the depth  $D$  coinciding so nearly with the value of  $i$ , we may, perhaps, make it clearer by considering the plates A and B of the diagram alone; and let us suppose these of equal areas and at distances from the neutral axis equal respectively to 10 and 9 feet. The true moments are—

Plate A, area= $A$ , leverage= $10$ , compression= $c$ ,  $\therefore$  moment= $10AC$   
 Plate B, area= $A$ , leverage= $9$ , compression= $\frac{9}{10}c$ ,  $\therefore$  moment= $8.1AC$

Sum of moments . . . . .  $18.1AC$

Dividing by the whole area  $= 2A$ , multiplied by the full compression we have  $c_2 = \frac{18.1AC}{2AC} = 9.05$  feet, or only six-tenths of an inch above the centre of the plate B.

To make this still more clear, let us compare the above arrangement of girder having the plates at 9 and 10 feet from the neutral axis, with a girder in which both plates are only 9 feet from the axis. Plate A in the latter acts with the same force  $C$  as in the former, but its leverage is reduced from 10 to 9 feet, so that its moment is reduced from  $10AC$  to  $9AC$

Plate B, on the other hand, acts in the latter with the same leverage of 9 feet as in the former, but the force of its action is increased from  $\frac{9}{10}C$  to  $C$ , and therefore its moment is increased from  $8.1AC$  to  $9AC$

Or the total moment . . . . .  $= 18AC$   
 being only  $\frac{1}{18.1}$  part less or weaker than the girder so much greater in extreme depth.

From these facts some valuable hints may be taken as to the judicious designing of the booms of girders.

2d. We shall conclude for the present with another general example.

Let the top boom be supposed to be a solid rectangle, as in some timber bridges and roofs. For this our formula  $D_2 = M_2 \div \text{area } C$  becomes simply

$$D_2 = \frac{1}{3} \left( h + i + \frac{i^2}{h} \right) \quad . \quad . \quad . \quad (3)$$

Assigning to  $h$  and  $i$  different relative values, we get the results in Table II.

TABLE II.

Ratio of $h$ to $i$ .			Values of $D_2$ .		Percentages of Error when $D$ is taken	
			Correct.	Usual.	As Usual. In Excess.	= $i$ . On safe side.
2	:	1	1.167	1.5	28.6	14.3
3	:	2	2.111	2.5	18.4	5.3
4	:	3	3.083	3.5	13.5	2.7
5	:	4	4.067	4.5	10.7	1.64
6	:	5	5.056	5.5	8.8	1.3
7	:	6	6.048	6.5	7.5	0.8
8	:	7	7.042	7.5	6.5	0.65
9	:	8	8.037	8.5	5.7	0.50
10	:	9	9.033	9.5	5.2	0.4

Edinburgh.

R. H. B.

*Passage, on the Level, of a Torrent across the Canal du Midi.*

From the Lond. Civ. Eng. and Arch. Journal, Aug., 1862.

Among the very interesting and instructive collection of models and drawings of French engineering works now in the International Exhibition, may be seen a model  $\frac{1}{25}$ th full size and two drawings, representing a work certainly unique in its character,—no other than the passage, on the level, of a torrent across a canal. The torrent in question is the Libron, which crosses the last level but one of the Canal du Midi (called the level de l'Ecluse Ronde), at a distance of 1300 metres from the Mediterranean. Often dry, and commonly containing but a scanty supply of water, the Libron suddenly assumes in wet weather the character of a violent torrent, bringing with it masses of sand and gravel, detached from the friable mountains and rocks among which it takes its rise.

At the point where it crosses the canal, the bottom of the bed of this torrent is even with the higher level of the water, which only exceeds the mean height of the sea by 90 centimetres, or about 3 feet. This circumstance rendered it impossible to construct such a work as would in ordinary cases be employed to keep an artificial watercourse clear of the natural streams with which it meets.

The inadequacy of the fall made it impossible to take the Libron under the canal by a syphon aqueduct, which would have been liable to get constantly choked with sand. And the carrying the canal by an aqueduct above the highest floods of the Libron, was also in a sense impracticable, since it would have involved raising the canal many metres above the level of the plain, for a distance of more than 20 kilometres (12 or 13 miles).

During the first years of the execution of the canal, the Libron had no determinate bed. After rains its waters spread over the plain and discharged themselves at many points into the level de l'Ecluse Ronde, filling it with sand and gravel to such an extent as to render dredging necessary to restore the navigation interrupted by these deposits.

The first step taken was to confine the waters to a single bed, and

carry the stream across the canal through a species of lock or basin having transverse and wing walls, the course of the canal through the lock being commonly open, but closed during the rains by strong dams; which were fixed by means of grooves in the masonry, and removed after the turbid waters had spent themselves. This arrangement confined the silting up of the bed of the canal to one spot; but the barges were stopped not only during the continuance of the floods, but also during the placing and removal of the dams, and the re-excavation of the basin.

Subsequently these interruptions of the navigation were shortened by placing in the basin a pontoon having its deck level with the bed of the stream, and having at its sides wooden bulwarks of sufficient height to convert it into a species of aqueduct deep enough to carry the flood waters. In ordinary weather this pontoon was moored on one side, out of the way. In seasons of flood it was placed across the basin, so as to form a distinct channel for the torrent, and while in this position it of course stopped the passage of the boats.

At length, after the stoppages of the year 1853 (which extended over no less than a hundred and five days), it was resolved, instead of replacing the pontoon, which had given way under the weight of gravel and sand deposited on it, to try to devise an expedient for keeping the navigation uninterrupted. This end was attained by means of the present work, of which the following is a description:

At the meeting of the Libron and canal two new beds or branches, symmetrically placed, were dug for the stream, starting at 50 metres above the canal, and reuniting at the same distance below it. These two branches, each of which is of equal section with the old bed, are separated by a basin exactly similar to a lock, and affording room for one boat.

In these two branches are placed, on each side of the canal, and in a direction parallel with it, an equal number of archways dividing each arm into bays, which can be closed against the stream by floodgates working in timber framing. By means of these floodgates the torrent can be stopped, and caused to flow through whichever channel is desired.

To keep the turbid waters from mingling with the waters of the canal, movable aqueducts or troughs of timber are provided, two in each bay, of the same width as the bays, and of a length equal to half the width of the canal. These troughs are suspended from trucks, which run on rails carried on vaults of masonry, which are built across the canal.

During floods the torrent passes alternately through each of the two branches, as they are opened and closed by the sluices. In the branch where the floodgates are open, the troughs are brought together, so as to cover the entire surface of the basin corresponding to each bay. While in this position they stop the passage of the boats. On the other hand, in the branch of which the floodgates are closed, the troughs are withdrawn into the recesses contained between the abutments of the vaults thrown over the canal and the arches, leaving

an open passage for the boats. These recesses are made deeper than the bed of the torrent in order to take the troughs, and are covered with movable flooring, to prevent the silting up which would otherwise impede the movement of the troughs.

It will readily be understood that from whichever side a boat approaches (during floods) the torrent is turned through the further channel, until the boat passes into the lock in the middle, where it is made fast. The troughs of the branch which the boat has to pass through are then run together, the flooring lowered, the sluices drawn up, and the torrent flows for some moments through both branches at once. As soon as the stream has set well on the side by which the boat entered, it is stopped in the other branch by closing first the up-stream and then the down-stream sluice. What water remains is run off into the canal by a valve provided in the partition of the troughs. The flooring in the recesses is then raised again, and the troughs are run back, leaving the passage open for the boat to continue its journey.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

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For the Journal of the Franklin Institute.

*Momentum.* By JOHN A. GRIER.

There is no term used by writers on the mechanical sciences that seems more important to define than this, and none which appears to have a more indefinite meaning.

By the term *momentum*, I mean "the force accumulated in a moving body." Two terms, *momentum* and *vis viva*, are generally used to express this accumulation of force. Sometimes it is defined as a quantity varying as the weight multiplied by the velocity,—then again as half the weight multiplied by the square of the velocity, and, again, as the weight multiplied by the square of the velocity. The latter is I believe the most generally accepted theory among the leading constructors of our railroads and bridges,—our armaments,—our engines and vessels.

If this large class of most eminent men made no mistakes, or taught no errors, I would not dare to pen this article. However, I will advocate no really new dogma, as Olmstead, Playfair, and Newton are among its supporters, yet I do not wish to hold them responsible for any of my own deductions.

I will endeavor to prove that the momentum or quantity of force accumulated in a moving body, varies as the weight multiplied by the velocity: and that the resistance a moving body will overcome, varies as the momentum, and that the velocity will vary as the quantity of force expended. The laws of gravity are so well understood, and for our present purpose are most convenient. The force of gravity is a uniform force, and hence in equal times, will exert equal quantities of force whenever it is left free to act upon a moving body. Omitting to take any account of atmospheric resistance, and neglecting what are in the present consideration unimportant fractions, we

find that a body near the surface of the earth left free to the action of gravity, or free to fall, will move through sixteen feet of space during the first second, and acquire a final velocity of thirty-two feet per second, and during two seconds will move through sixty-four feet of space, and acquire a final velocity of sixty-four feet per second.

By inquiring into the cause of this increased space moved through and increased velocity acquired during the last of the two seconds, we see that it is most easily explained. The uniform force of gravity is exerted on the moving body equally during each of the two seconds, yet the results at first sight do not appear the same. As we have seen during the first second, sixteen feet is moved through and a final velocity of thirty-two feet per second is acquired, while during the last second, forty-eight feet is moved through, and a final velocity of sixty-four feet per second is acquired. However, we wish to prove that the expenditure of force is the same during each second, and also, that although a body in this case moves over four times as much space in two seconds, as it does during the first of these two seconds, still the *space moved through, is no true criterion of the force expended, or of the resistance overcome.*

Gravity exerting its full force on this body for one second moves it through sixteen feet, and gives it a final velocity of thirty-two feet per second; this final velocity will carry the body through the next thirty-two feet during the last of the two seconds without any extra expenditure of force by gravity, but the body receiving the same quota of force during the last second that it did during the first, hence the body is moved through forty-eight feet during the last second, and acquires a final velocity of sixty-four feet per second.

Thus it appears that although the space moved through during two seconds, is four times as great as that moved through during the first of these two seconds, when a body is left free to the influence of the force of gravity, yet the quota of force expended during two seconds is *not* four times as great as the quota of force expended during the first of these two seconds.

Hence "*the actual work done,*" "*the resistance overcome,*" "*the mechanical effect,*" "*the force accumulated or stored up in the moving body,*" "*the momentum,*" "*the vis viva,*" or by whatever term we may choose to call *this result* of the action, of the uniform force of gravity on the moving body, is only twice as great for two seconds as it is for the first of these two seconds.

At any point of descent a body would return to the height from which it fell, if all the force expended on it down to that point were left free to act upon it in an upward direction. At the end of two seconds as the velocity of the falling body is sixty-four feet per second, then let it commence to ascend at that point; during the first second of its ascent it will move through forty-eight feet, and have a final velocity of thirty-two feet per second, and during the next second it will go through sixteen feet, and have a final velocity reduced to zero.

Hence again it is true that the work done or resistance overcome in the first of these two ascending seconds, is equal to that done during the last of these two ascending seconds. Because the only resistance

overcome is the uniform force of gravity which resists the ascending body with a certain definite quota of force during each second of the time it is left free to act. The *time* during which any uniform force acts freely on a body, and *not the space* through which it moves the body, is the only unvarying and true criterion of the work done, or of the force stored up, or accumulated in the moving body. *If* the force expended by gravity during two seconds is four times as great as the force expended during the first of these two seconds, then the accumulated force should be four times as great at the end of the two seconds, as it would be at the end of the first of these two.

We have shown that this quadruple force has not been *expended* and hence it is not *accumulated*. As the velocity varies as the time, then the force accumulated varies as the velocity, or as the weight into the velocity. *Thus a double expenditure of force gives a double velocity, and a double velocity gives a double momentum. Hence the momentum will vary as the weight multiplied by the velocity.*

If we measure the force accumulated in a moving body by the length of time it is expending this accumulated force in overcoming a resistance uniform *as to the time*, then it is evident that it varies as the weight multiplied into the velocity.

But if we measure the force accumulated by the force expended in overcoming a resistance uniform as to the time, but *not uniform as to the space*, by the space through which a body is moved while the accumulated force is being expended, then it will vary as the weight multiplied by the velocity squared.

The former of these measures is usually called *momentum*, while the latter is called *vis viva*, and in reality there is no more difference between their meaning, than if we at one time should say a yard was three feet, and at another time thirty-six inches in length: momentum being the term used when the element *time* is taken into consideration, *vis viva* when *space* is taken into consideration. But when the resistance is not *uniform as to the space*, space cannot be a true criterion of the force expended; hence the term *vis viva* understood in this way is very indefinite. From this simple cause alone arises the great confusion of ideas on this subject.

Some persons may consider this a dispute about words only, but when we see authors of eminent practical abilities, such as Bourne the great English engineer, boldly teach that the momentum of a moving body varies as the weight multiplied by the *square of the velocity*, and that it is necessary to double the expenditure of force to obtain a double velocity; it is most evident that the dispute is not only about words.

It is on this hypothesis that he advances and endeavors to prove that the force necessary to be expended in overcoming the front resistance of a vertical plane moving through a fluid in a vertical direction, will vary as the *cube of the velocity*.

This theory is so generally believed, I almost fear that the prejudice in favor of it alone, may prevent many from ever giving this article a patient thought.

In the study of the abstruse subject of fluid resistance, my attention was first attracted to the confusion of theories taught on this vital principle of momentum. It is fit, then, that I should mention it in connexion with the present subject. The bearing that this question has on projectiles and iron-clads is also eminently practical.

Does the resistance a shot would overcome vary as the weight into the final velocity, or as the weight into the square of the final velocity, other things being equal? Our deductions would teach us to believe in the former of these measures, in opposition to the theory usually taught by practical men on such matters.

Both in steamship propulsion and in gunnery there are so many varying elements brought to bear in developing the force as well as in expending it, that it is impossible to determine the exact quota of force expended in overcoming each species of resistance.

I will conclude this article with an account of some crude experiments I have made, having a relation to this subject.

I dropped a small iron rod from the height of four feet so that it acquired a velocity of sixteen feet per second, and then dropped the same rod through sixteen feet, so that it acquired a final velocity of thirty-two feet per second, and on measuring their respective penetration in sand found that *the penetration varied as the velocity*.

Then I dropped a rod of the same sectional area, but of half the length of the first one, from the height of sixteen feet so that it acquired a final velocity of thirty-two feet per second. Its penetration in the sand was the same as the larger one dropping with a final velocity of sixteen feet per second. These results were not mathematically as I have stated, but the average penetration in these crudely conducted experiments is all I profess to give. To me they appeared as very conclusive evidence that the penetration of shot, other things being equal, will vary as the weight into the velocity, or as their momenta.

I also arranged a delicate steel spring with a trigger attached, so that I could let it re-act suddenly when compressed.

A weight bent it one degree, a double weight two of these degrees of tension, a triple weight three degrees. On allowing the spring to re-act at one degree of tension, it would throw a shot lying on it a certain height, but when let go at two degrees it would throw the shot to four times the former height, and at three degrees to nine times the height. Thus again seeming to prove that a double force would throw the body to a quadrupled height, and a triple force to nine times the height. The time the force of gravity would act on the respective ascending shots would vary as one, two, and three for their respective efforts.

These experiments were but rudely executed, but in all their simplicity they seemed to be very conclusive.

I hope a patient reading of this brief article *may do something* towards reconciling any discrepancy that may exist on this most important and interesting subject.



*The Principles of Spectrum Analysis.* By THOMAS ROWNEY.

From the London Intellectual Observer, June, 1862.

Sixty years or more ago Dr. Wollaston detected in the spectrum obtained from solar light a series of dark bands crossing it throughout its entire length. These lines may be easily seen through a prismatic telescope, of which Mr. Crookes has contrived a simple form. The discoverer does not appear to have thought much of the fact, and seems to have discontinued his experiments, as we have no further account of his researches in that direction. It was not until Fraunhofer of Munich announced his independent discovery of the same lines, and showed that they were constant both in number and position, and mapped them out to the extent of more than 600, with the most sedulous care, that they came to be regarded as features worth notice. He showed that these lines, which now bear his name, might be found in all spectra, by viewing them through a telescope, whether the source of light were the sun, moon, fixed stars, or planets. He also found them in the electric spark, and in flames colored by the combustion of metals. These two philosophers might justly lay claim to the honor of having laid the foundation of what is now termed spectrum chemistry. In the words of Dr. Miller :

“The inquiry thus launched by Fraunhofer has been followed in four principal branches of research, which may be described as relating to,—

“1. *Cosmical lines*, or the black lines produced in the light of the sun, the planetary bodies, and the fixed stars.

“2. *Black lines produced by absorption*, a class of phenomena discovered by Sir D. Brewster, in his observations upon the red vapors of nitrous acid.

“3. *Bright lines produced by the electric spark*, when taken between different conductors.

“4. *Bright lines produced by colored flames*, or by the introduction of different substances into flames.

“The following chronological table contains the names of those who have made the principal steps in these different subjects :—

“ Newton	.	.	1701.
Wollaston	.	.	1802.
Fraunhofer	.	.	1815.
COSMICAL.			ABSORPTION BANDS.
Brewster,	1832.	Brewster,	1832.
E. Becquerel,	1842.	W. H. Miller	} 1833.
Draper,	1842.	and Daniel,	
Stokes,	1852.	W. A. Miller,	1845.
Brewster and	} 1860.		
Gladstone,			

## ELECTRIC LIGHT.

Wheatstone, 1835.  
 Foucault, 1849.  
 Masson, 1851—55.  
 Angstrom, 1853.  
 Alter, 1854—55.  
 Secchi, 1855.  
 Plückner, 1858—59.  
 V. Willigen, 1859.

## COLORED FLAMES.

Brewster, 1822.  
 Herschel, 1822.  
 Fox Talbot, 1826, 1833, 1834.  
 W. A. Miller, 1845.  
 Swan, 1857.

Kirchhoff . . . 1859.  
 Kirchhoff and Bunsen . . . 1860."

In order to a right understanding of the results which have been reached by the recent labors of Kirchhoff and Bunsen, it is necessary to be acquainted with the nature of the dark lines, which are so many touchstones or tests by which they have worked them out. Let us suppose a prism of blue glass to be used for effecting the decomposition of a ray of solar light. We have an elongated image, not, however, containing seven colors, as when a white prism is used. The yellow, blue, and green are all absorbed, and we have only the two extreme colors, violet and red, the latter also diminished in breadth. A comparison with the normal spectrum will make the difference at once clear. In passing through our atmosphere, or the atmosphere of the sun, similar changes may take place, and thus materially assist in producing these dark lines. Moreover, there are a class of rays in the solar spectrum which our eyes cannot see, and of which we can only judge by their effects. Of such are the chemical rays which manifest their action in the beautiful results of the photographic art. We may instance also another set found beyond the violet rays, whose presence has been demonstrated by Professor Stokes, by transmitting them through a solution of sulphate of quinine. They have a light bluish-lavender color. Thus, it will seem that certain rays have such a refrangibility that our eyes cannot take cognizance of them; and so also certain rays exist in solar light which are incapable of transmission through certain media. Applying this to the solar spectrum, we have a clue to the production of the dark lines, by supposing, with Kirchhoff and Bunsen, that the sun has the property of inducing or giving out rays of a certain refrangibility, but yet cannot produce others capable of filling the interspaces. Another interpretation has been given, by supposing an interference in the undulations of certain rays, which produce darkness; but this theory will not meet the circumstances of the case, and we can show by experiment that by making an artificial atmosphere the same or parallel results can be produced.

The natural variations in the composition of the atmosphere produce similar effects, and Brewster was the first to notice bands in the red and green spaces, whose appearance was not constant. These appearances are usually observed when the sun is not far from our horizon; and Dr. Miller mentions an instance in which he saw a group of lines

during a thunder shower. They came suddenly, and faded as the rain passed away.

The readiness with which the spectrum responds to changes in the atmosphere, or in the nature of the source of light, is shown in the following experiment of Kirchhoff and Bunsen:—

They threw up into the air of the apartment a small quantity of chloride of sodium in very fine powder. Motion was imparted to the atmosphere, to insure an equable diffusion of the salt. The spectrum in an instant demonstrated its presence, by showing a golden-yellow band in the yellow space. This effect is uniform whenever sodium is present in a state of incandescence, and is therefore called the sodium spectrum. This result might have been expected, knowing that sodium in any form always tinges flame an intense yellow; but when we come to the combustion of other metals, the bands produced by them are such as could never have been anticipated. When silver is burnt we have other colored bands brought out equally characteristic, and so with every other metallic substance. To show the relation between these colored bands and the dark lines, we will suppose the light of a pure white flame to be passed through a yellow sodium flame, and then through the prism. Now, mark the change. The spectrum is no longer continuous, and having its bright yellow band in the yellow space; but where it flashed out so conspicuously is now to be seen a dark line, known as “D.” The rationale is obvious. The yellow atmosphere has interfered with the yellow of our normal spectrum, and by that interference darkness has resulted.

Keeping these results in view, we have a key to the whole subject of spectrum chemistry. It can be shown that each metal in a state of vapor has the power to arrest particular rays with a constancy that can be relied on. The arrangement best suited for these experiments is either Dubosq’s electric lamp, or the Drummond light, but many of the spectra may be conveniently studied by using Crookes’s spectroscope, as made by Spencer Browning and Co., and now too well known to need detailed description. This instrument is well adapted for ordinary purposes, but to appreciate the full beauty and delicacy of the various spectra, we should need an apparatus as perfect as that constructed for Kirchhoff by Steinheil of Munich.

When artificial light is employed—as that of gas or lamp—the dark lines may be brought out by interposing a glass trough or bottle containing nitrous acid gas between the light and the instrument. This gas may be obtained by the action of a small quantity of nitric acid on a piece of copper; and, as we have before mentioned, it acts as an absorptive medium. If a piece of sulphur be introduced into the flame of a spirit-lamp, a good view of its dark bands may be obtained. If the subject for examination be an alkaline metal, the spirit-lamp may be used, or better still, a flame of hydrogen mixed with air and burnt on the top of a tube covered with wire gauze. We thus obtain a flame of high temperature with little light, except what is derived from the substance employed. The metal in a state of chloride is the most convenient form—it being more easily volatilized. It may be introduced

into the cotton wick; or if the gas-burner be used, then a loop of platinum wire sliding on an upright support is the easiest to manage. The copper spectrum may be readily obtained by dipping a coil of fine wire into pure hydrochloric acid, and immediately inserting it into the gas-flame. When iron, silver, &c., are operated upon, wires of these metals should form the electrodes of a powerful voltaic battery, and be brought by its agency to an incandescent state, when a portion of their substance is volatilized, and exhibits its characteristic action through the prism.

Kirchhoff and Bunsen, while pursuing their researches on the composition of some mineral water, obtained from the combustion of the solid matter a series of bands in two spectra, which did not correspond with those produced by any of the known metals. This led them to infer the presence of some new elements which the eye of man had never yet seen. After evaporating several tons of the fluid, their labors were rewarded by obtaining two new metals, which they named Cæsium (greyish blue)—that being the color of the bands—and Rubidium (dark red). No sooner had they done this than they were off into the depths of speculation, conceiving that they had in their power a means of analysis capable of much higher application.

These ingenious and indefatigable workers found that the bright lines in the metallic spectra corresponded closely with the dark lines of the solar spectrum. Why was this? and how could it be explained? They found, by experiments before cited, that each color was opaque to rays of its own color.

To illustrate the point more clearly, we may suppose two pendulums of equal length to be placed side by side. If the one be made to vibrate, it will, after a time, cause its companion to do the same in consequence of its equal length or isochronous condition; and so it is supposed that the rays of one color will be taken up by another whose vibrations are of equal length, and so be arrested in their voyage. Now look at the application of this result. If, in the rays of light from an artificial source, this principle be correct, it may also be correct with the rays of solar light. Hence they have inferred that the dark bands of the solar spectra are produced by their passage through an atmosphere containing certain metals in a state of high combustion or vapor.

Upon these grounds they have concluded that in the outermost solar envelope exist all those metals in a state of vapor, whose color-bands coincide with dark lines of the solar spectrum, as sodium, potassium, iron, and nickel; and that it is by the more powerful light of the photosphere shining through this only feebly-luminous layer that the dark bands of Fraunhofer are produced by the process before described. They have also inferred the source from which these metals are derived to be the mass of the sun. A bold assertion, perhaps a correct one; but we are certainly not at present justified in accepting it as if it were proved; and we may advantageously reflect upon the words of Dr. Miller:—

“Fascinating as this theory is, it must be remembered that it is yet

upon its trial, and that it does not explain the facts at present known respecting the vapors of hydrogen, mercury, chlorine, bromine, iodine, and nitrogen. M. Morren even questions the accuracy of some of Kirchhoff's observations. Thus, he states that in a measurement which he made of the red band of potassium, conjointly with Plücker, they found that it did not correspond with the solar line A, but that it is considerably more refrangible."

There are many other important facts which will have to be considered before we can arrive at a complete theory of the spectral phenomenon. For example, chloride of lithium produces a single crimson line in the flame of a Bunsen burner; the greater heat of a hydrogen flame enables it to emit an orange ray, and the voltaic arc adds a brilliant stripe of blue. In like manner, iron and other metals furnish spectra which advance in complication as the temperature of their vapor is increased.

Professor Roscoe says that "the general rule is that *luminous solids* give off a different *quality of light* when they are differently heated, and luminous gases give off the same kind of light at all temperatures." The spectra of gases are quite as interesting as those of the metals; hydrogen, for example, giving a red and a blue band, and nitrogen beautiful violet stripes.

### *On the use of Mica for Preserving Gilding, &c.*

From the *Mechanics Magazine*, August, 1862.

In Paris, mica has lately been applied for preserving, silvering, and gilding decorations in churches and public buildings. The mica is first cut to the desired thickness with a knife, and is then coated with a thin layer of isinglass diluted in water, and the gold or other substance is applied, after which it is allowed to dry. A pattern of copper, with a design cut out on it, is then placed on the reverse side of the mica and the superfluous parts are removed. The colors are then applied in one or several coats, and the whole afterwards coated with a solution of isinglass and diluted alcohol, by which the mica is rendered pliable. When this is effected, the mica is applied to the object, which is coated with glue or other adhesive material, and allowed to become comparatively dry, after which the surface is made smooth by rubbing it gently with an agate burnishing tool. The value of mica depends on the size of the sheets and their transparency, the clear ruby-tinged being the finest, and the cloudy grey the least valuable.

### *Mountain Barometer.*

From the *Intellectual Observer*, July, 1862.

Under this title Messrs. Horne and Thornthwaite have produced a very excellent aneroid, especially adapted to facilitate the measurement of heights. Being only  $2\frac{1}{2}$  inches in diameter, it is very portable, while from the excellent workmanship, no practical loss of efficiency is the consequence of its reduced size. The face is graduated in two

circles, the outer one giving the barometrical pressure in inches and tenths of an inch. Below this is the second circle, upon which the peculiar convenience of the instrument depends. This is graduated in spaces corresponding with hundreds and thousands of feet, so that a mere inspection is sufficient, without any calculation, for the measurement of ordinary heights. Thus, if the hand points to 1000, and on being carried to an elevation indicates 1100, it is evident that the last station is 100 feet higher than the first. Where the elevation to be measured is considerable, there will be a difference of temperature between the upper and lower levels, which must be allowed for to obtain a correct result; and the makers of this instrument supply a convenient and easily worked table, calculated in degrees of Fahrenheit according to the formula of La Place. To test the accuracy of the instrument, we have made repeated trials with heights of 20 or 30 feet and upwards, always obtaining closely approximate results. We have also compared its indications with a mercurial barometer, and observed its prompt indications of slight changes in the density of the air. We have likewise carried it loose in our pockets during long walks, and on two railway journeys, to see if a good shaking would do it any harm. The result of these experiments has been very satisfactory, and we can, therefore, recommend it to the tourist as a pleasant companion, serving the double purpose of a good barometer and measurer of heights.

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### *Proceedings of the Association for the prevention of Steam Boiler Explosions.*

From the Journal of the Society of Arts, No. 509.

At the ordinary monthly meeting of the Executive Committee of the Association, held July 30th, Mr. L. E. Fletcher, chief engineer, presented his monthly report, of which the following is an abstract:—

During the last month there have been examined 323 engines and 563 boilers. Of the latter, two have been examined specially, one internally, 95 thoroughly, and 465 externally, in which the following defects have been found:—Fracture, 16 (2 dangerous); corrosion, 46 (8 dangerous); safety-valves out of order, 11 (1 dangerous); water gauges ditto, 19 (4 dangerous); pressure gauges ditto, 14; feed apparatus ditto, 11; blow-off cocks ditto, 28 (1 dangerous); fusible plugs ditto, 6; furnaces out of shape, 10 (3 dangerous); blistered plates, 7; total, 168 (19 dangerous). Boilers without glass water gauges, 12; without pressure gauges, 2; without blow-off cocks 50; without back pressure valves, 98.

Three explosions occurring during the past month, to boilers not under the inspection of this Association, have come to my knowledge. One of these took place in Manchester, the other in the neighborhood of Newcastle, and the third in London, while all three were attended with fatal consequences. The plates of the first are reported as having been found on subsequent investigation so reduced by corrosion, as not to have exceeded the thickness of a sheet of paper; while it is

worthy of remark, with regard to the second, that its explosion had seriously damaged another boiler alongside of it, which, however, fortunately happened at the time to be out of work, or, from the injuries it received, it must have exploded in turn. This is frequently found to be the case, and the fact is of interest, as affording an indication of the variety of forces developed by explosion, which, as has been previously pointed out, evidently cannot be summed up merely in that of disruption and the re-action consequent on unbalanced pressure.

In addition to the above, however, it becomes my duty to report the occurrence of an explosion to one of the boilers belonging to a member of this Association, and which, it is to be regretted, was attended with loss of life to the fireman.

This is the third fatal explosion which has happened to any of the boilers under the inspection of this Association since its establishment, nearly eight years ago, to which should be added three cases of collapse of furnace flues, not attended with any serious consequences, and which arose in two instances, if not in all three, from shortness of water. During this period, 656 dangerous defects have been pointed out in the boilers under inspection, from which serious injury might have arisen in each case; while, upon limited inquiry only, it has been found that no less than 202 fatal explosions have occurred in that time to boilers not under the inspection of this Association, which have been attended with the loss of 438 lives, in addition to serious injury to 476 persons, and considerable damage to property.

The explosion last referred to occurred to one of a pair of ordinary cylindrical double-flued boilers, working side by side and connected together. Both boilers were upon mid-feathers, and were of precisely similar construction and dimensions, the length of each being 34 feet, the diameter of the shells 7 feet, of the flues 2 feet 7½ inches, and the thickness of plates  $\frac{3}{8}$ ths of an inch throughout, with the exception of the flat ends, which were  $\frac{1}{8}$ ths of an inch. The fittings consisted in each case of a glass water-gauge; a back pressure and feed stop-valve combined; a blow-out valve, of mushroom construction, opening against the pressure in the boiler; and a lever safety-valve, loaded with a single weight to a pressure of 35 lbs. per square inch; in addition to a steam pressure gauge common to both boilers as long as both junction-valves were open, but not otherwise.

The explosion was occasioned by a rent in the shell, which took place directly through the line of rivets, at one of the longitudinal seams in the second ring of plates from the front of the boiler, the seam being on the right-hand side, three feet from the centre or "keel" line at the bottom. The construction of the seam was such that the edge of the outer plate was uppermost.

The cause of the rent was thinning of the plates at this seam, by external corrosion, through which it had become reduced to about  $\frac{1}{16}$ th of an inch in thickness. The corrosion extended throughout the length of the seam, which was 2 ft. 6 ins., and affected the plates on both sides of the lap to a width of from four to six inches. The rent did not extend longitudinally beyond the limit of this ring of plates, but ran along

the transverse seams of rivets on each side of it, almost severing a complete belt from the boiler. The re-action from this opening raised the boiler momentarily almost on end, as was attested by the character of the fracture of the connexions, the indentations in the bottom plates, and the fact that a pipe, previously overhead, had become buried beneath it, while the twin boiler along side was blown bodily in a lateral direction. Had the longitudinal seams of the rivets, instead of breaking joint, been in line, which is too frequently the case, the rent would certainly have run from one end of the boiler to the other, and the destruction of property, and very probably that of life also, have been most serious.

This defect was one that could scarcely have escaped detection on a careful examination of the condition of the plates in the external flues. Still, it should be borne in mind that the plates of boilers set on mid-feathers are neither as accessible nor as visible as they are in those set on two side walls with a split flue. The side flues in the latter case admit of coming face to face with the plates and seams in a manner which cannot be done in the former, in which many of them can only be seen obliquely at a very great disadvantage, while those at the upper part of the flue, in what may be termed the tip of the wing, are frequently out of reach altogether.

All the members must be aware that, for the express purpose of detecting such defects as the above, the association affords, in addition to the external inspections, the opportunity of having every boiler "internally and thoroughly" examined at least once a year. The importance of these "thorough" examinations has been repeatedly called attention to, and every opportunity taken to promote their being made, and, in order to suit the convenience of members as to time, the ordinary routine of visits is entirely set aside at holiday times, such as Whitweek, Christmas, Easter, and race weeks, so that the inspectors may exclusively devote themselves to this special service.

It is much to be regretted that the Association was not afforded the opportunity of making a "thorough" examination of this boiler, either in the year 1860 or 1861, and when, in consequence of attention being specially called to this omission, our inspector, at the request of the owners, visited the works last Easter, the boiler was found unprepared, the flues being imperfectly swept, and the plates coated with soot, although the visit had been expressly appointed, in order to effect a "thorough" examination. Under these circumstances, no satisfactory examination could be made, which was distinctly stated to the engineer at the time, and subsequently officially reported to the owners. So clearly was this understood, that the next time the boiler was stopped the manager of the works went up the flue himself in order to complete the examination, which the want of preparation had previously prevented our inspector from doing.

It is hoped that our members will see from this the absolute necessity of having their boilers prepared for examination. They certainly cannot fail to remember how constantly this has been pressed upon their attention. A note referring to it appears at the foot of every



notice forwarded to them of the inspector's proposed visit, and another in the report on his examination, while reference was made to the subject in the chief engineer's monthly report for June, sent to each member; and, in addition, attention is frequently called by special letter, as it was in the present instance. Had it not been for its practical importance, so much had not been said upon so uninteresting a subject, and apology has sometimes been felt necessary for its frequent introduction. Still, dry or not dry, it is often a question of explosion or no explosion.

Yet another word before dismissing this subject. To expect an inspector to wait while the flues are being swept, as is too frequently the case, is really unreasonable, and compliance could only result in the accommodation of one member at the expense of another, while it would induce such disorder and breach of appointments as would only lead to a general dead-lock, especially in such a thronged time as every holiday week is, when the inspectors have one continuous string of engagements for these "thorough" examinations, from its beginning to its close, many of them being fixed for more than a month previously.

It may be added that the engineer who lost his life had been in the habit of going up the flues every month after they had been swept, and yet did not detect the corroded seam. This either shows that the corroded plate was concealed from view in some way in which it was impossible to account for after the explosion, or else is a witness to the necessity of competent inspection. That sweeps cannot be trusted to do engineering work is also clear.

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For the Journal of the Franklin Institute.

### *Notes of Shipbuilding and the Construction of Machinery in New York and Vicinity.*

Notwithstanding the dark clouds of civil war which hang over our country at the present period, there is great activity manifested in the various ship-yards and machine-shops of New York and vicinity. It is true that the prominent feature of the work in progress comprises the construction of vessels of war for our Government, demanded by the exigencies of the times; but they do not monopolize the whole of it, as during the past year many magnificent steamships of large tonnage have been constructed for private individuals, and others are now on the stocks, or undergoing the process of completion. Many of these vessels, however, have been sold, or chartered for an indefinite period, to the Government, and now are being used as gunboats or transports.

It is an indisputable fact that the shipping interests of the Northern States have been for the past fifty years steadily on the increase, and but temporarily interfered with by the several financial crises we have passed through in that time. Although we have never boasted of the immensity of our tonnage, we have advanced with that steady and marked progress which has attracted towards us the attention of European countries, and they have expressed their astonishment at our

enterprise and energy in Naval Architecture, and the excellency of our machinery.

Science and art have extended their aid in no other department of handiwork more particularly than in this, and the appreciation of the fact that our models of vessels, and the skill and ingenuity manifested in their construction, are universally regarded as of a superior order, is practically shown by numerous foreign nations, who fly their ensigns over the decks of many formidable men-of-war composing their fleets, whose construction is due to American skill and American ingenuity. And more than this, many of their citizens are owners of vessels of fine models, well constructed, sent forth from our yards, and now plying their seas.

If more evidence of this character is required to prove my assertion, I think the fact that special agents, recently sent to this country by foreign powers to superintend the erection of vessels intended for them, now being constructed at the yard of one of our most successful shipbuilders, will certainly be sufficient.

During the past few days I have visited the several ship-yards and machine-shops to be found within New York and vicinity, and as a result of my observations and inquiries, I present herewith annexed a review of the operations for the past six or eight months, together with those now in progress. It will give an impression of the state of the business, and as a matter of future reference alone they are of much interest :

*The Steamer Continental.*—Hull built by Samuel Sneden & Co., Greenpoint, L. I. Machinery constructed by Morgan Iron Works, New York. Owners, New York and New Haven Steamboat Co. Route of service, New York to New Haven.

*Hull.*—Length on deck, 282 ft. 6 ins. Breadth of Beam, 35 ft. 8 ins. Depth of hold, 11 ft. 5 ins. Draft of water, 6 ft. 6 ins. Frames—molded, 6 ins.—sided, 12 ins.—apart at centres, 24 ins. Tonnage, 1130 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 70 inches. Length of stroke of piston, 11 ft.

*Boilers.*—Two—tubular—located on guards, and have one blower to each.

*Paddle Wheels.*—Diameter over boards, 34 ft. No. of blades, 32. Material, wood.

*Remarks.*—This steamer is built of white oak, &c., and around her frames diagonal and double laid iron straps are running.

*The Steamers City of Boston and City of New York.*—Hulls built by Sneden & Rowland, Greenpoint, L. I. Machinery constructed by Novelty Iron Works, New York. Superintendent of construction, Capt. Comstock. Route of service, Norwich to New York. Owners, Norwich and New York Transportation Co.

*Hulls.*—Length on deck, 300 ft. Breadth of beam, 37 ft. 6 ins. Depth of hold, 13 ft. Draft of water, 7 ft. 6 ins. Frames, strapped with diagonal and double laid iron braces. Tonnage, 1424 tons

*Engines.*—Vertical beam. Diameter of cylinder, 75 ins. Length of stroke of piston, 12 ft.

*Boilers.*—Two to each vessel—tubular—located on guards, and have one blower to each

*Paddle Wheels.*—Diameter over boards, 37 ft. 8 ins. Material, wood.

*Remarks.*—These vessels are of white oak throughout. Each have patent water-tight compartments, which, although there are doors for passing in and out to the several saloons, can be closed, and made impervious to water in a moment of emergency. They have eighty-five state-rooms each, capable of accommodating two hundred and fifty-five persons. In addition to this, each boat has some three hundred other berths, so that six hundred passengers can, at any one time, find ample room and pleasant accommodations. Each state-room has double partitions. The precautions against fire are admirable and unique. No lights are allowed in the rooms, but the saloons are so brilliantly lighted that almost sufficient light strikes through the ground-glass panels of the doors for reading purposes. The saloons are all elegantly fitted up, and very large, the main upper saloon in each vessel being 225 feet in length.

*The Steamer Stars and Stripes.*—Hull built by C. Mallory, Mystic, Conn. Machinery constructed by C. H. Delamater, New York. In Government service.

*Hull.*—Length on deck, 150 ft. 6 ins. Breadth of beam, 34 ft. 6 ins. Depth of hold, 8 ft. Draft of water, 9 ft. Frames—molded, 13 ins.—sided, 8 ins.—apart at centres, 24 ins. They are securely fastened and strapped with iron braces, diagonally and double laid. Rig—three-masted schooner. Tonnage, 410 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 26 ins. Length of stroke of piston, 2 ft. 6 ins.

*Boilers.*—One—tubular—located in hold, and uses a blower.

*Propeller.*—Diameter, 9 ft. Pitch, 16 ft. Material, cast iron.

*Remarks.*—This vessel is constructed of white oak, chestnut, &c., and put together in a masterly manner. She was originally intended for service on the route between New York and New Haven, but upon her completion she was purchased by the National Government, and since then has done excellent blockading duty upon the Southern coast.

*The Steamer Santiago de Cuba.*—Hull built by J. Simonson & Co., Greenpoint, L. I. Machinery constructed by Neptune Iron Works, New York. Superintendent of construction, Wm. D. Phelps. In Government service.

*Hull.*—Length of keel, 219 ft. Length on deck, 240 ft. Breadth of beam, 38 ft. Breadth over wheel houses, 52 ft. Depth of hold, 19 ft. 6 ins. Depth of hold to spar deck, 27 ft. Draft of water, 14 ft. Frames—molded, 15 ins.—sided, 18 ins.—apart at centres, 26 ins. Rig—Brigantine. Tonnage, 1650 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 66 ins. Length of stroke of piston, 11 ft.

*Boilers.*—Two—flue. Length, 30 ft. Height, 12 ft. Breadth, 12 ft.

*Paddle Wheels.*—Diameter over boards, 29 ft. Length of blades, 9 ft. 6 ins. Number, 22. Diameter of shaft, 17 ins. Material, iron.

*Remarks.*—This vessel was intended as the pioneer of a line of steamers between the port of New York and St. Jago de Cuba, and was originally owned by Messrs. Valienti & Co., of the latter place. Her frames are of white oak, haemetac, chestnut, &c., and square fastened, with copper and treenails. Her keel is of white oak, sided 12 ins. and moulded 15 ins.; the floor is solid to the floor timber-heads, fore and aft. Stem and stern posts of white oak; the inner stern-post and apron of live oak. Main keelson, 15 by 16 ins., and sister keelsons, two on each side, 12 by 12 ins. Bilge keelson, 12 by 12 ins., extending the whole length of the ship. The vessel is diagonally strapped with  $4\frac{1}{2}$  and  $\frac{7}{8}$  inch iron straps, from bilge to second deck, and has an iron strap of same dimensions running entirely around the ship inside. The planking is of oak. Each beam in the lower deck is well supported with bosom and lodging knees. Ceiling in lower hold—five strakes of 9 ins. thick, balance 7 ins. thick. All the arrangements of this steamer were such, that at the time she was finished she was surpassed by few steamships afloat.

*The Steamer Paquette de Maule.*—Hull built by Lawrence & Foulks, Williamsburgh, L. I. Machinery constructed by Neptune Iron Works, New York. Owners, Geo. K. Stevenson & Co., Valparaiso. Route of service, Valparaiso to Maule, coast of Chili.

*Hull.*—Length on deck, 165 ft. Breadth of beam, 29 ft. Depth of hold, 9 ft. Depth of hold to spar deck, 9 ft. Draft of water, 8 ft. 6 ins. Frames—molded, 12 ins.—sided, 6 ins.—apart at centres, 24 ins. These frames are square fastened with copper and treenails, and are strapped with diagonal and double laid braces,  $4\frac{1}{2}$  by 7-16 ins. Rig—Brigantine. Tonnage, 400 tons.

*Engines.*—Vertical beam. Diameter of cylinders, 32 ins. Length of stroke of piston, 8 ft.

*Boilers.*—Two—flue—located in hold, and do not use blowers.

*Paddle Wheels.*—Diameter over boards, 24 ft. Material, wood.

*Remarks.*—This vessel is of white oak and locust, and constructed in the most thorough manner. She was the first vessel ever built in this country for the trade in which she is engaged, and this fact may be considered a recognition of the superiority of our Naval Architecture, as those steamers previously employed where the *Paquette de Maule* is running, have never fulfilled the requirements of the locality. The interests of the Chilian Government have heretofore secured the patronage of shipowners there for English shipbuilders, but by the untiring exertions of Messrs. Lawrence & Foulks, American skill achieves another triumph.

*The Steamer Mercedita.*—Hull built by Edward Lupton, Williamsburgh, L. I. Machinery constructed by Murphy, McCredy & Worden, New York. In Government service.

*Hull.*—Length at load line, 180 ft. Length on deck, 195 ft. Breadth of beam, 30 ft. Depth of hold, 11 ft. 3 ins. Depth of hold to spar deck, 19 ft. Draft of water 10 ft. Frames—molded, 14 ins.—sided,  $7\frac{1}{2}$  ins.—apart at centres, 30 ins. Rig, Schooner. Masts, two. Bulkheads, two. Tonnage 840 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 30 inches. Length of stroke of piston, 2 ft. 8 ins.

*Boilers.*—Two—horizontal tubular. Length, 16 ft. 6 ins. Breadth, 7 ft. 10 ins. Height, 8 ft. 4 ins. No. of furnaces, two to each. Breadth, 3 ft. 4 ins. Length of grate bars, 6 ft. 6 ins. No. of tubes above, 70. No. of flues below, 4. Internal diameter of tubes above, 4 ins. Do. flues below, 10½ and 19 ins. Length of tubes above, 10 ft. 6 ins. Do. flues below, 4 ft. Heating surface, 2500 sq. ft. Grate surface, 86 sq. ft. Diameter of smoke pipe, 4 ft. 4 ins.

*Propeller.*—Diameter, 10 ft. Pitch, 18 ft. No. of blades, 4. Material, cast iron.

*Remarks.*—This vessel was the first of four steamers intended to ply between Texas, New York, and Havana, but so soon as completed she passed into the hands of the United States. She was constructed with a view to attain great strength and speed. She is built of white oak, hachmetac, and chestnut, and is ceiled with yellow pine. Instead of using iron straps as braces for her frames, she has every four feet over her ceiling diagonal oak braces, 9 by 2½ inches, making five inches in thickness, running from upper deck clamp to fifteen inches below floor heads, each intersection being bolted with iron, and all the treenails passing through the ship and wedging in these braces—thus forming, it is asserted, a greater strength than was ever before attained in a vessel of her class.

*The Steamer Shantung.*—Hull built by Thomas Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Owners, Everitt & Co. Route of service, coast of China.

*Hull.*—Length on deck, 150 ft. Breadth of beam, 25 ft. 6 ins. Depth of hold, 10 ft. Depth of hold to spar deck, 17 ft. 6 ins. Draft of water, 7 ft. Frames—molded, 12 ins.—sided, 5 and 6 ins.—apart at centres, 26 ins. They are square fastened with copper and treenails, and are braced with iron straps, diagonally and double laid, 3½ by ¾ ins., extending entirely around them. Rig, Schooner. Tonnage, 520 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 36 ins. Length of stroke of piston, 10 ft.

*Boilers.*—One—flue—located in hold, and uses a blower.

*Paddle Wheels.*—Diameter over boards, 22 ft. Material, iron.

*Remarks.*—This steamer is constructed of white oak and chestnut, and put together in a masterly manner. Her model is without fault. The reputation which Mr. Collyer achieved in China for building steamships, was surpassed by no other Contractor. He sent to the seas of that empire some eight or ten vessels, all of which have beat, in many an exciting race, the boasted steamers of England.

*The Steamer Flambeau.*—Hull built by Lawrence & Foulks, Williamsburgh, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. In Government service.

*Hull.*—Length on deck, 185 ft. Breadth of beam, 30 ft. Depth of hold, 11 ft. Depth of hold to spar deck, 18 ft. Draft of water, 10 ft. 6 ins. Frames—molded, 11 ins.—sided, 8 ins.—apart at centres, 30 ins. These frames are square fastened with copper and treenails, strengthened in the best possible manner by iron straps, diagonally and double laid, 4 by ½ in., extending around them. Rig, Brigantine. Tonnage, 791 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 5 ft.

*Boilers.*—Two—tubular. Located in hold.

*Propeller.*—Diameter, 10 ft. Pitch, 18 ft. No. of blades, 4. Material, cast iron.

*Remarks.*—This steamer was built for Messrs. P. S. Forbes & Co., and was intended for service on the coast of China, but owing to her excellent construction she was taken by the National Government at the period of her completion. She is built in a masterly manner, of white oak, chestnut, &c., and is of beautiful model. The builders of her machinery had two objects in view at the time of its construction, viz: great strength and speed, and the trips she has made have proved very conclusively to them that they have succeeded even beyond their most sanguine expectations.

*The Steamer Honduras.*—Hull built by Thomas Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Owners, L. H. Ackerman and others. Route of service, Honduras to Cuba.

*Hull.*—Length on deck, 150 ft. Breadth of beam, 26 ft. Depth of hold, 10 ft. Draft of water, 7 ft. Frames—molded, 12 ins.—sided, 5 and 7 ins.—apart at centres, 28 ins. These frames are square fastened with copper and treenails, and have iron straps, diagonally and double laid,  $3\frac{1}{2}$  by  $\frac{3}{8}$  ins., running around them. Rig, Schooner. Tonnage, 375 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 36 inches. Length of stroke of piston, 8 ft.

*Boilers.*—One—flue—located in hold, and has no blower.

*Paddle Wheels.*—Diameter over boards, 22 ft. Material, iron.

*Remarks.*—This vessel is built of white oak and chestnut, and has all the requirements for an excellent sea-going steamer.

*The Steamer Constitution.*—Hull built by Wm. H. Webb, New York. Machinery constructed by Novelty Iron Works, New York. Superintendent of construction, Capt. Francis Skiddy. Commander, A. T. Fletcher. Owners, Pacific Mail Steamship Co. Route of service, San Francisco to Panama.

*Hull.*—Length on deck, 333 ft. Do. over all, 364 ft. Breadth of beam, 44 ft. Depth of hold, 23 ft. 6 ins. Do. to spar deck, 31 ft. 6 ins. Draft of water, 20 ft. Frames—molded, 15 ins.—sided, 18 ins.—apart at centres, 36 ins. These frames are fitted in solid, and have iron straps, diagonally and double laid,  $4\frac{1}{2}$  by  $\frac{7}{8}$  ins., running around them, securing them in the best possible manner. Rig, Brig. Tonnage, 3446 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 105 ins. Length of stroke of piston, 12 ft. Diameter of piston rod,  $11\frac{1}{2}$  ins. Diameter of crank pin journal, 14 ins. Length of do., 18 ins. Diameter of beam centre journals,  $15\frac{1}{2}$  ins. Length of do. 21 ins.

*Boilers.*—Four—flue. Diameter of shell, 13 ft. 3 ins. Length of boilers, 32 ft. Height, 14 ft. Diameter of steam drum, 8 ft. Diameter of smoke pipe, 7 ft. Height of do. 41 ft. Five cylindrical furnaces in each boiler—diameter, 40 ins. Fire surface in each boiler, 3300 sq. ft. Grate surface, do., 115 sq. ft.

*Paddle Wheels.*—Diameter of water wheel outside of buckets, 40 ft. Length of buckets, 18 ft. Width of do., 24 ins. Diameter of water wheel shaft journal, 22 ins. Length of do., 30 ins.

This steamer has Sewell's surface condenser, fitted with 5500 brass tubes, 9 ft. long, the condensing of which equals 8000 sq. ft.

*Remarks.*—This vessel is built of live oak, chestnut, hacmetac, &c. She embraces all the modern improvements for securing great strength, safety and comfort. For securing proper ventilation, the state-rooms are very large, and lattice-work is secured in every position to insure a full and free circulation of air in all the apartments. Imperfect ventilation has been the prevailing defect in former Pacific steamers. Such evils are remedied in the *Constitution*. The hatches and all the important openings are about double the size of those in most steamers, and ventilating hoods are applied to operate alike to atmospheric siphons to remove the hot air, and take in a constant supply of cold air. Two large blowers are also used for ventilation.

*The Steamer James F. Freeborn.*—Hull built by Lawrence & Foulks, Williamsburg, L. I. Machinery constructed by Fletcher, Harrison & Co., New York. Commander, Capt. O. Morrell. Owners, Richard M. Squires and others.

*Hull.*—Length on deck, 155 ft. Breadth of beam, 26 ft. Depth of hold, 9 ft. 8 ins. Draft of water, 5 ft. 6 ins. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 26 ins. Tonnage, 380 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 9 ft.

*Boilers.*—One—flue. Diameter of shell, 10 ft. 3 ins. Breadth of front, 11 ft. Length, 23 ft. Steam chimney, 50 ins. internal, and 86 ins. external diameter. It has two furnaces, 7 ft. 6 ins. in length, and is fitted with 26 flues. Heating surface, 1805 sq. ft. Grate surface, 75 sq. ft. There are 23 sq. ft. of heating surface to each cubic foot of cylinder, and 24 ft. of heating surface to one of grate.

*Paddle Wheels.*—Diameter, 22 ft. Face, 8 ft. Dip, 38 ins. Have 22-inch buckets.

*Remarks.*—This vessel is built of oak, chestnut, and hacmetac; frames double throughout; filled in solid for 50 feet from the stern. Keelsons of yellow and white pine, 7 in number, 14 by 14 inches. Bilge strakes of oak and yellow pine, 4 in number, 5 ins. thick, 12 ins. wide each. Ceiling throughout of yellow pine, 3 ins. thick; oak strings  $4\frac{1}{2}$  by 14 ins. Bottom planks of oak, 3 ins. thick. Deck beams 6 by 6 ins., of yellow pine. Hanging knees in hold, of hacmetac. Stevens' cut-off is applied to the engine. B.

New York, November 15, 1862.

(To be Continued.)

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*Of the Earthquake-Wave Experiments made at Holyhead.*

BY ROBERT MALLET, Esq., C. E., F. R. S.

(Abstract.)

This communication contributes the sequel of the author's "Report on Earthquake-Wave Experiments" (made at Holyhead), as published in part 3 of the "Philosophical Transactions" for 1861. At the conclusion of that paper the author expressed his hope of being able soon to lay before the Royal Society some experiments for the determination of the modulus of elasticity of perfectly solid portions of both the slate and the quartz rock formation through which his wave-transit experiments had been made at Holyhead, with a view to throw light

upon the relations between the theoretic velocity of transmission (if the rocks were all solid and homogeneous) and the actual velocity as determined by experiment.

He has now determined the elastic modulus for both rocks, and for each rock in two directions, viz: parallel to and transverse to its lamination; and he has extended his determinations to specimens of each rock of maximum and of minimum compactness and hardness, so that the series of experiments upon the compressibility of these rocks (from which the modulus is derived) assumes the following divarication, viz. :—

Slate rock . .	Hardest . .	{ B. Parallel to laminæ, Table 2. A. Transverse to laminæ, Table 1.
	Softest . .	{ F. Parallel to laminæ, Table 6. E. Transverse to laminæ, Table 5.
Quartz rock. .	Hardest . .	{ D. Parallel to laminæ, Table 4. C. Transverse to laminæ, Table 3.
	Softest . .	{ H. Parallel to laminæ, Table 8. G. Transverse to laminæ, Table 7.

Involving thus eight distinct series of experiments.

The compressions were conducted at the Royal Arsenal, Woolwich, by the aid of the excellent American machine belonging to the Royal Gun-factories, permission to use which was accorded to the author.

The specimens of rock submitted to pressure were all equal cubes of 0·707 inch on the edge, presenting thus a surface on each side of 0·5 square inch—a dimension presenting facilities for tabular reduction, &c.

The cubes were cut from the chosen rock specimens (selected with care as fairly representative) by means of the lapidary's wheel, and had opposite faces rigidly parallel and equal.

The pressures advanced by 1000 lbs. per square inch of surface, from zero up to the crushing point of the specimen; and at each advance the actual compression of the column of rock was measured by instrumental arrangements that admitted of reading space to ·0005 of an inch. The results are given in tables numbered 1 to 8, referred to above, and these are compared in two tables numbered 9 and 10.

The following are the mean compressions for each 1000 lbs. per square inch :—

Slates.				Quartz.			
A.	B.	E.	F.	C.	D.	G.	H.
inches. ·000627	inches. ·0025000	inches. ·0039144	inches. ·0037000	inches. ·0007085	inches. ·0010947	inches. ·0014666	inches. ·0172666
up to 23,000 lbs.	up to 26,000 lbs.	up to 14,000 lbs.	up to 7000 lbs.	up to 35,000 lbs.	up to 19,000 lbs.	up to 12,000 lbs.	up to 6,000 lbs.

Crushing usually took place at 1000 to 2000 lbs. additional pressures beyond the above limits, up to which the compressions were tolerably uniform.

The discussion of these tables fully presents some interesting and novel results.



Generally the quartz rock is less compressible than the slate; the softest quartz, however, is much more compressible than the softest slate in a direction parallel to the lamination of both. In this direction also the hardest slate is more than double as compressible as the hardest quartz. Transverse to the lamination, however, both the hardest slate and quartz have nearly the same co-efficient of compressibility, which is very small for both. In the latter direction also the *softest* slate and quartz have almost the same co-efficient, but one about *four times* as great as for the *hardest* like rocks.

The author points out several conclusions of much interest deducible from these experiments as to the physical and geological conditions under which these rocks were formed and consolidated. The compression by natural forces has already been greatest in directions transverse to the lamination. The great compressibility in the opposite directions, or parallel to the lamination, appears to arise chiefly from the mass of the rock being made up of minute wedge-shaped mineral particles, deposited all with their largest dimensions on the plane of lamination, and so acting on each other like wedges.

Some curious circumstances in the mode of giving way of the rocks under pressure are shown by the author to be probably connected with their mass being formed of an aggregate of several simple minerals.

He points out the great differences in wave-transmissive power in directions transverse to and parallel to the lamination which these experiments disclose. The specific gravities of the several specimens of rock are then given, to enable the modulus of elasticity to be obtained in feet, and the general results of the experiments are comprised in the following table (p. 48):—

The author then proceeds to apply these results to the comparison of the theoretic and actual transit-periods of the wave of impulse.

The general expression for elastic wave-propagation in a homogeneous medium may be expressed by an equation of the form

$$v = \sqrt{gL} = 8.024\sqrt{L},$$

where  $L$  is the modulus of elasticity in feet. Where, from want of homogeneity or shattering, &c., as found in nature, the experimental value of  $v$  differs from this, we may express it by the same form of equation,

$$v' = \alpha\sqrt{L},$$

the co-efficient  $\alpha$  having to  $\sqrt{2g}$  the rate that the actual bears to the theoretic value of  $v$ .

He then determines the value of  $\alpha$  for three of his mean experimental transit-velocities at Holyhead, and obtains as follows:—

Feet per side.

$v' = 1089$	$\alpha = 0.637$
$v' = 1352$	$\alpha = 0.791$
$v' = 1220$	$\alpha = 0.714$

HOLYHEAD ROCK COMPRESSION.  
*General results reduced, modulus of cohesion and of elasticity, &c.—Slate and Quartz.*

No.	Class of rock, and direction of pressure in relation to structure.	Co-efficient of compression on unit surface for 1000 lbs.	Elastic limit for compression.	Crushing load on the unit of surface.	Modulus of cohesion (compression).	Modulus of elasticity.	Modulus of elasticity.	Co-efficient $T_r$ .
		inches.	lbs.	lbs.	feet.	lbs.	feet.	
1	Slate <i>hardest</i> across lamination. . . . .	·0006217	22,000	24,000	20,014	8,042,454	6,706,524	1·2432
2	Quartz <i>hardest</i> across lamination. . . . .	·0007085	32,000	37,000	32,095	7,057,163	6,121,758	2·1830
3	Slate <i>hardest</i> parallel to lamination. . . . .	·0025000	18,000	27,000	22,515	2,000,000	1,667,778	5·6241
4	Quartz <i>hardest</i> parallel to lamination. . . . .	·0010317	17,000	20,000	17,349	4,567,461	3,962,013	1·8240
5	Slate <i>softest</i> across lamination. . . . .	·0039144	12,000	15,000	12,586	1,277,335	1,071,769	4·8930
6	Quartz <i>softest</i> across lamination. . . . .	·0014666	11,000	14,000	12,158	3,409,246	2,960,699	1·7108
7	Slate <i>softest</i> parallel to lamination. . . . .	·0037000	6,000	9,000	7,552	1,351,351	1,133,874	2·7747
8	Quartz <i>softest</i> parallel to lamination. . . . .	·0172666	7,000	8,000	6,948	289,576	251,477	11·6112
<i>Calculated Means.</i>								
9	Slate, mean for hard and soft across lamination. . . . .	·0022080	17,000	19,500	16,311	2,204,585	1,844,069	3·6855
10	Quartz, mean for hard and soft across lamination. . . . .	·0010885	16,500	25,500	22,132	4,597,701	3,990,455	2·3103
11	Slate, mean for hard and soft parallel to lamination. . . . .	·0031000	12,000	18,000	15,056	1,612,903	1,349,145	4·6494
12	Quartz, mean for hard and soft parallel to lamination. . . . .	·0091806	12,000	14,000	12,151	544,627	472,684	10·7100
<i>Calculated Means of Means.</i>								
13	Slate, hard and soft, mean for both directions (Nos. 9 and 11). . . . .	·0026810	14,500	18,750	15,681	1,862,880	1,566,541	4·1914
14	Quartz, hard and soft, mean for both directions (Nos. 10 and 12). . . . .	·0051340	16,750	19,750	17,141	973,899	845,252	8·4490
15	General mean for slate and quartz, hard and soft, and in both directions (Nos. 13 and 14). . . . .	·0039090	15,625	19,250	16,398	1,279,099	1,089,615	6·2697

The actual velocity of wave-transmission in the slate and quartz rocks, taken together, was to the theoretic velocity due to their materials, if perfectly solid,

$$a : \sqrt{2g}, \text{ or as } 1.00 : 8.89 ;$$

so that nearly eight-ninths of the full velocity of wave-transmission due to the solid material is lost by reason of the heterogeneity and discontinuity or shattering of the rocky mass as it is piled together in nature.

The author then shows that were the rocks *quite solid*, the velocity of wave-transmission would be—

Mean of slate and quartz transverse to lamination  $v = 13,715$  feet per second.

Mean of slate and quartz parallel to lamination  $v = 7659$  feet per second.

This difference is probably reversed *in nature* by reason of the greater discontinuity in the former direction. The author then shows that his results, which appear at first sight to conflict with those of an analogous character obtained by Helmholtz and others for wood, in the three principal directions of its section, are strictly in accordance and analogy with the results of these experimenters.

The author concludes by deducing some conclusions as to the bearing power, safe load, and proper direction as to lamination when exposed to pressure, of these rocks, of a practical character, and valuable to the civil engineer or architect.

Proc Royal Society, May 8, 1862.

### *On Steam-Boiler Explosions.*

From the London Chemical News, No. 144.

*The Decomposed Steam Hypothesis.*—The unsatisfactory results generally obtained by those who have sought to decompose water by heat on a large scale, with the view of applying its elementary gases separately, do not appear to have prevented the occasional adoption of the hypothesis that, in certain cases, all the steam contained within a boiler is decomposed, and its hydrogen (by some means not easily explained) exploded with great violence. That steam, passed over pure metallic iron heated to redness, is decomposed, is perfectly true, although the iron must retain all the oxygen separated in the operation. With oxidized iron, however, the process of decomposition cannot be continued. This is, we believe, a chemical fact of which there can be no dispute. To decompose 1 lb. of water (or steam, which is chemically the same substance) 14.2 oz. of oxygen must be fixed by the iron, and only 1.8 oz. of hydrogen will be set free. This large proportion of oxygen, absorbed by only a few square feet of over-heated surfaces, would soon form an oxide of iron of sufficient thickness to arrest all further decomposition, and all the hydrogen up to that time disengaged would not amount, perhaps, to 1 lb. in weight. By itself, or mixed with steam, hydrogen cannot be exploded, nor even ignited. It will extinguish flame as effectually as would water.

Upon this subject we may refer to a report made by Professor Faraday in May, 1859, to the Board of Trade upon the liability to accident consequent upon the introduction of an apparatus for superheating steam on board the Woolwich steamboats. In this apparatus the steam was carried in iron pipes immediately through the furnace, and in contact with the incandescent fuel. Professor Faraday, after having examined the apparatus at work, says:—

“I am of opinion that all is safe, *i. e.*, that, as respects the decomposition of the steam by the heated iron of the tube and the separation of hydrogen, no new danger is incurred. Under extreme circumstances the hydrogen which could be evolved would be very small in quantity—would not exert greater expansive force than the steam—would not with steam form an explosive mixture—would not be able to burn with explosion, and probably not at all if it, with the steam, escaped through an aperture into the air, or even into the fire-place.

“Supposing the tubes were frequently heated over much, a slow oxidation of the iron might continue to go on within; this would be accompanied by a more rapid oxidation of the exterior iron surface, and the two causes would combine to the gradual injury of the tube. But that would be an effect coming under the cognizance of the engineer, and would require repair in the ordinary manner. I do not consider even this action likely to occur in any serious degree. I examined a tube, which had been used many months, which did not show the effect; and no harm or danger to the public could happen from such a cause.”

Professor Taylor, of Guy's Hospital, reported in part, as follows, upon the same apparatus:—

“It is true that steam passed over pure metallic iron heated to redness ( $1000^{\circ}$ ) is so decomposed that the oxygen is fixed by the iron while hydrogen gas is liberated. This chemical action, however, is of a very limited kind. The surface of the iron is rapidly covered with a fixed and impermeable layer of the magnetic oxide of iron, and thenceforth the chemical action is completely arrested. If the interior of an iron pipe has been already oxidized, by passing through it, while in a heated state, a current of air, there will be no decomposition of steam during its passage through it. If the interior of an iron pipe were not thus previously oxidized, it would speedily become so by the oxygen derived from the air, which is always mixed with steam. Hence, chemically speaking, under no circumstances, in my opinion, would any danger attend the process of superheating steam as it is conducted under this patent. It is proper, also, to state that hydrogen is not explosive, but simply combustible, and assuming that it was liberated as a result of the decomposition of superheated steam, its property of combustibility would not be manifested in the midst of the enormous quantity of aqueous vapor liberated with it and condensed around it. There could be no explosion, inasmuch as hydrogen, unless previously mixed with oxygen, does not explode; and oxygen is not liberated but actually fixed by the iron in this process. It is a demonstrable fact that the vapor and gas evolved under the form of

superheated steam, tend to extinguish flame and to prevent combustion from any other cause."

Professor Brande, in a report made by him to the patentees of the same apparatus, observes:—

"In reference to the question which you have submitted to me, respecting the possible or probable evolution of hydrogen gas and consequent risk of explosion in the processes, and by means of the apparatus which you employ for the production of superheated steam, I am of opinion that there can be no danger from such effect, that the temperature to which the iron pipes connected with your boiler are raised, and the extent of the iron surface over which the steam passes, are insufficient for its decomposition; and that if the temperature of the pipes were even raised considerably beyond that which you employ, or would be able to attain, a superficial layer of oxide of iron would line the interior of the heated pipes, and so prevent any continuous decomposition of water. Effectually to decompose steam, by passing it over iron, it is necessary that a very extended surface of the metal (as in the form of thin plates or iron turnings) should be used, and that the temperature should be continuously maintained at a bright red heat, namely, at a temperature considerably above  $1000^{\circ}$  Fah. I have read Dr. Taylor's report, and entirely agree with the inferences he has drawn as to the absence of danger from the evolution of hydrogen gas in practically carrying out your process for the production and application of superheated steam."

The practical conclusions upon this subject are the following:—1. Decomposition cannot possibly occur, to any considerable extent, under any circumstances arising in the working of ordinary steam boilers. 2. If it did occur, the hydrogen thus liberated would have no access to oxygen, without which it could neither inflame nor explode. 3. Even if oxygen were present, the presence of steam would prevent ignition. 4. If oxygen were present, and no steam existed in the boiler, the hydrogen would only inflame and burn silently as fast as it was produced, the heat for ignition being supposed to come from a red-hot plate. Under these accumulated impossibilities of violent explosive action, the explanation of boiler explosions by the decomposition of steam is without any support whatever.

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#### *On Boiler Deposits and Incrustations.\**

From the *Practical Mechanic's Journal*, Sept. 1862.

In presenting to the Institution of Civil Engineers of Ireland the following translation of M. Couste's Memoir on Boiler Deposits, by Mr. Robt. Trefusis Mallet, now employed as a resident engineer upon the Great East Indian Railway, Bengal, it may be desirable to preface it by a brief statement of the principal conditions that affect questions of the nature, formation, or prevention of boiler deposits.

The importance of the subject to mechanical engineering, and to the public, cannot be overrated. The efficient exclusion of deposits

\* From a Memoir about being published in the Transactions of the Institution of Civil Engineers of Ireland.

and incrustations from innumerable land boilers of Great Britain alone, would involve the economization of millions of tons of fuel—the preservation of many lives periodically destroyed by explosion, often traceable to this as one in the train of causes; while if perfected in marine boilers, it would revolutionize much of our steamship machinery. That such possible results are recognised, is proved by the fact that more than seventy patents encumber the records at this moment, for methods presumed to mitigate or to prevent deposit or incrustation of boilers; yet amongst these it may be affirmed that there is not even one that fully answers its purpose, while the great mass consist of mere “nostrums,” that only prove the general ignorance of the conditions in the problem by the inventors and by the public. I do not, therefore, suppose that any apology is required from me on the part of the translator of M. Couste’s most valuable memoir, although its first appearance in its original language dates some years back; for I am myself aware that, owing probably to its having been inaccessible except in a foreign tongue, it has remained up to the present time almost completely unknown to British mechanical engineers. Yet it contains a rigorous investigation of some of the most important conditions upon which depend the *only* method so far effective for the prevention of boiler deposits, namely—the continuous removal of determinate volumes of the heated fluid, so as to avoid saturation and deposition, whether partial or total.

M. Couste touches but slightly upon the chemical or mineralogical parts of the subject; he deals principally with its thermic and dynamic relations.

I propose, therefore, to preface the translation of his memoir by passing the former very briefly in review, and referring as briefly to some of the modes, patent or otherwise, proposed as remedies, and chiefly dependent on chemical relations.

Exclusive of “mine waters,” or other natural waters, mineralized or polluted, and hence everywhere to be shunned for feeding boilers, and therefore rather beside our subject, the natural waters with which steam boilers are supplied for evaporation, may be divided into—1st, Fresh water; 2d, Sea water; and the questions for the practical engineer refer to the nature of their solid contents, the causes and order of deposit of these, and to the action of their solid contents upon the boiler.

The primary effects of the solid contents of the water ceasing to remain in solution as when introduced to the boiler are, 1st, Deposition, and at a further and more or less prolonged stage, Incrustation; i. e., the induration of the previously unintegrated precipitate, whether morphous or finely crystalline.

And the immediate consequences are—

1. Interference with the full functions of the boiler in supplying steam.
2. The promotion of its destructive action by the fire and flame of the fuel upon its shell.

While the remoter consequences is the danger of explosion induced, which becomes extreme when the deposit is thick and diffused.

The destructive re-action upon the boiler again is two-fold—

1. Mechanical.—The deposit or incrustation preventing the free passage of heat to the water through the shell of the boiler, causing waste of fuel and overheating of the boiler, and interfering (in various constructions of boiler) with the free circulation of the fluid, upon which the rapid taking up of heat by it so much depends.

To treat fully of the last would involve the passing in review a great number of different forms and constructions of boiler, and be quite beyond our scope here.

It is enough to say, that obviously boilers with intricate interior construction, closely placed tubes and water spaces, &c., will be most liable, *cæteris paribus*, to this injurious result.

2. Chemical.—Corrosion and destruction of the metal of the boiler due to the action of more concentrated saline matter, soluble and insoluble; and to that of the air and gases of the furnace acting on the metal brought to a higher temperature.

Both effects under this head are modified by the nature of the metal of which the boiler is constructed; and practically our steam boilers may be classed as either of iron or of copper, or of some few of the alloys of the latter.

Boilers of iron are most acted on by air and water, and by some of the saline contents of fresh and sea water when concentrated; while copper boilers (once strongly advocated for marine purposes) are more affected by the oxidized sulphur of the coal, by the ammonia evolved from its combustion, and by the oily acids of the grease pumped into and spread about the boiler. It should be remarked in passing, however, that when sulphurous fuel is burnt at an intensely high temperature in direct contact with the boiler shell, iron is acted on with great rapidity (whether with or without internal deposits), and apparently by the direct formation, at the external surface of the iron shell, of successive thin coats of bi-sulphuret of iron; hence it is, as one cause, that copper fire-boxes possess their durability in locomotive fire-boxes. There are other and independent reasons for this durability, however.

In the class of natural fresh waters, the substances *most commonly* found dissolved are lime, soda, iron, magnesia, potass, alumina, and silica (the relative quantities being *usually* in the order here set down), and in combination with oxygen, chlorine, occasionally with oxidized nitrogen, in the form of nitrates and carbonic acid.

Organic compounds of carbon, hydrogen, and nitrogen, are also often present. Besides these, natural fresh waters contain air in solution, often with excess of oxygen, carbonic acid, uncombined with solid bases, and more rarely sulphuretted hydrogen.

The analysis of Thames water by Dr. R. D. Thompson, as supplied by some of the London Water Companies, may be taken as a type

of our common hard waters, receptive (more or less) of putrescible matter—and hence of such as most commonly supply our land steam boilers.

In this city (Dublin) the well waters from the limestone gravel are much more rich in sulphate of lime, which is still more the case in the waters, for example, of the Paris Gypseous Basin. Hence, in so far, the latter are both worse than the London water as steam boiler supply—sulphate of lime forming, in fact, both in land and marine boilers, the most insoluble and intractable portion of any deposit formed.

The solid matters contained in one imperial gallon of Thames water, according to the above chemist, are—

THAMES WATER				
Chloride of Sodium,	.	.	.	16·00 grains.
Sulphate of Potass,	.	.	.	2·41
Chloride of Magnesium,	.	.	.	2·10
Carbonate of Magnesia,	.	.	.	0·50
Chloride of Calcium,	.	.	.	2·11
Nitrate of Lime,	.	.	.	0·07
Sulphate of Lime,	.	.	.	3·18
Carbonate of Lime,	.	.	.	10·70
Oxide of Iron and Alumina,	.	.	.	0·46
Silica,	.	.	.	0·24
Organic Matter,	.	.	.	3·56
Total,				41·33

A boiler fed with such water (and this is not a remarkably impure one), a locomotive, for example, blowing off into steam 1000 gallons per hour, would, at the end of 350 hours, if no deposit or solid matter were blown out or otherwise removed, contain nearly a ton of sediment.

An imperial gallon of water is capable of holding dissolved when cold (60° Fahr.), and when boiling in free air (212° Fahr.), the following weights nearly, of the more important of the preceding salts:—

	At 60° Fahr.	At 212° Fahr.
Carbonate of Lime,	merely traces.	merely traces.
Silica,	70 grains.	"
Sulphate of Lime,	170 grains.	"
Carbonate of Magnesia,	3·25 oz.	"
Sulphate of Potass,	10 oz.	40 oz.
Chloride of Sodium,	32 oz.	32 oz.
Chloride of Magnesium,	266 oz.	580 oz.
Nitrate of Lime,	500 oz.	" ?
Chloride of Calcium,	540 oz.	unlimited.

It will thus be evident that the order of depositions, as the water in the boiler becomes concentrated, is—

1. Carbonate of Lime,
2. Sulphate of Lime,
3. The Salts of Iron, as Basis or Oxides, and some of those of Magnesia,
4. The Silica and Alumina, usually with more or less of the Organic Matter,
5. Common Salt.

The carbonate of lime sometimes deposits as an amorphous mass, like hard, fawn-colored chalk, but much more usually, especially in high pressure boilers, precipitates in the crystalline form, as arragonite



(one of the dimorphous forms, of which calc spar is the other). The sulphate of lime falls as amorphous gypsum most commonly, but not unfrequently in small crystals of hydrated gypsum, (the water combined in unusual proportions, as in those discovered, some years ago, by the late Professor Johnson of Durham, Reports Brit. Ass.) segregated or coherent as a hard crust—which latter forms the worst form of “boiler scale”—and when long exposed to high temperature, becomes changed to anhydrite, with the form of crystal, and hardness of the natural mineral.

Recurring now to marine boilers, or those fed with sea or salt water—our second class,

We may take Bouillon La Grange and Vogel’s analysis of the ocean water outside Bayonne, in the Gulf of Gascony, as a type of sea water. The total saline contents in a cubic foot of sea water varies, but within limits, in the ocean, and all the great tracks of navigation, that may be practically neglected. The freshest water is probably that of the Baltic, and upper part of the Black Seas—sp. gr., about 1024. The upper limit of salt is in the water of the Dead Sea—sp. gr., 1240 nearly.

The following are the solid contents of 100 parts of the Gulf of Gascony:—

Chloride of Sodium,	.	.	.	.	2.510
Chloride of Magnesium,	.	.	.	.	0.350
Sulphate of Magnesia,	.	.	.	.	0.578
Carbonate of Lime and of Magnesia,	.	.	.	.	0.020
Sulphate of Lime,	.	.	.	.	0.015
Carbonic Acid (in solution),	.	.	.	.	0.023
					3.496

The essential solid elements, as regards our subject, are the lime, sea salt and magnesia, in combination with sulphuric acid and chlorine, and very often in practice that which analysis does not show, a vast amount of suspended muddy water, which is pumped with the water into the boilers, as in the Ganges, British Channel, &c.

In minute quantity sea water, however, also contains potass, alumina, and various metals, with bromine and iodine.

The following table, by Berthier, shows the order and proportionate deposition of solid matter upon concentration, by boiling off steam from sea water, per 100 parts.

Saline Matter.	A Sea Water. sp. gr., 1.0278.	B Ditto. Concentrated sp. gr., 1.140.	C Ditto. Concentrated sp. gr., 1.220.	D Ditto. Concentrated Salt nearly Deposited.
Chloride of Sodium, . . .	2.50	16.00	25.50	20.80
Chloride of Magnesium, . . .	0.35	0.46	1.07	4.85
Sulphate of Magnesia, . . .	0.58	0.80	1.48	9.50
Carbon. of Lime and Magnesia, .	0.02	0.00	0.00	0.00
Sulphate of Lime, . . .	0.01	0.00	0.00	0.00
Sulphate of Soda, . . .	0.00	2.65	2.81	0.00
Water, . . . . .	95.54	79.79	69.14	64.85
	100	100	100	100

Thus when sea water is boiled down so that the water is only about 65 per cent.—all the salts of lime and magnesia—the whole of the sulphate of soda formed, and a large proportion of the sea salt have been deposited, and these constitute the tough and hard cake of salt, with imperfect crystallization, arranged perpendicularly to the heated surface, *i. e.*, the shell, that is so destructive and inconvenient in marine boilers.

In the state of concentration of D, the sea water is a strong brine, with a high boiling point. The elevation of the latter is shown by the following table, from Faraday's past experiments:—

Volume of Sea Water.	Boiling Temper. at 30° Barom.	Saline Matter in 100 parts.	Nature of the Deposit.
1000	214° Fahr.	3.0	None.
299	217° “	10.0	Sulphate of Lime.
102	228° “	29.5	Common Salt.

Thirty-seven parts of common salt saturate 100 of water, at all temperatures, if both be pure, according to Fuchs, but when the other contents of sea water are present, 36 parts saturate at 226° Fahr., and 30 parts at 228°. The loss of solubility *augmenting* with the temperature, hence 10 volumes of sea water concentrated to one, becomes, in part, saturated brine.

M. Couste has noticed also analogous facts with reference to the sulphate of lime.

We may now pass briefly in review the several methods that have been proposed or tried for mitigating or preventing these injurious deposits. To attempt to go through these *seriatim*, or even the patented ones only, would be impossible, and a bootless labor. They may be classed, however, under the following heads:—and first, as respects land boilers evaporating fresh water.

1. Filtration of the water—an obvious preliminary that should invariably be adopted when the water contains suspended mineral matter, but which does not affect dissolved salt, for, although long continued filtration and moving contact with solids, such as flint pebbles, will deprive water even of some of its soluble contents, the process carried to this extent is too costly for our purpose.
2. The application of collecting vessels to the boilers. These are of two sorts. A, external close vessels, heated by otherwise waste flue heat, into which the feed water of the boiler is primarily admitted, and passes thence to the boiler.

The function of such a vessel is that the lime held in solution as bi-carbonate, by the excess of carbonic acid dissolved in the water, is partially precipitated in the vessel as carbonate, the carbonic acid being driven off by the heat.

This constitutes Brunton's patent for sediment vessels.

It has also been proposed to adopt Dr. Clarke's water purifying process to the feed water entering boilers, and to precipitate the bi-carbonate of lime by adding measured volumes of

lime water, so as to form proto-carbonate. Like all other devices that aim at changing the water by chemical means, however, it is too delicate in application, and any excess of lime would obviously only add to the evil.

I may state here, upon the authority of my own researches of past years, that the carbonic acid is evolved, and the carbonate of lime begins to deposit, as soon as the feed water is heated to 190° Fahr.—(Reports Brit. Ass. Reports on Iron Corrosion.)

B, Internal collecting vessels, proposed by many separate inventors long since, and patented several years ago by Mr. Scott. These contrivances depend upon the fact that the solid matter when first separated from solution, and floating about in the agitated boiling water of the boiler, will find a resting place, and precipitate, *i. e.*, collect, in any part of the boiler, where we may provide for it a quiet spot, free from agitation of the water.

Hence, if a narrow necked vessel, as a bottle or pan, be placed within or hung up in a steam boiler, the water, though at 212° within it, does not circulate in brisk currents, and gradually the floating particles, as they pass its mouth, fall into this collecting vessel, deposit, and never return from it. This does in reality constitute one of the most efficient means known of collecting the deposit to one point, so as to preserve the rest of the boiler surface free, comparatively. It can be readily removed from the collecting vessel.

To this division belongs also the plan often adopted, of putting balls of wood, or brick, or stone, &c., into the boiler, which roll about with the agitated water, and segregate some of the deposit in coat after coat upon their surfaces. This notion is very ancient, and has been known in domestic life—housewives putting a boy's marble into their teakettles with a similar object.

The two methods, A and B, may be combined; and I have in my own practice found the combination advantageous—an external sediment vessel heated by the waste flue heat receiving the feed water, and in it the greater part of the carbonate of lime is left; while internal collecting vessels in the boiler receive the greater part of the remainder, in combination with the sulphate of lime. This method also, though long previously in use, has been patented by Taylor.

3. The addition of foreign materials to the water of the boiler, with a view to prevent the aggregation of the particles of the deposit, and their adherence to the walls of the boiler.

The substances proposed with this end in view are numerous.

Potatoes, oatmeal, bran, sawdust, molasses, coal-tar, charcoal dust, smiths' dust,—*i. e.*, finely divided coke and ashes,—coal ashes, plumbago, soap, tallow, and many others have been added in more or less bulk to the water in the boiler before closing the main lid after cleaning. All of these, and more especially such matters as potatoes or sawdust, possess some power of subdividing and making more friable

calcareous deposits, and are not without some use when much sulphate of lime is present in the water, as they greatly interfere with its crystallization into massive crusts; but their effort is temporary, and all such additions are attended more or less with the serious evils of "priming," *i. e.* water being driven over with the steam into the steam pipes and valves of the engine from the boiler, and with it solid matter, which chokes the passages, spoils the valve faces, &c. To this class of mitigants belongs the useless and expensive nostrum long in use "by authority" in the Royal Navy, of coating the whole inside shell of the boiler (in steam ships) with tallow and black lead mixed together, under the notion that it prevented the adhesion of deposited salt. It is believed that this is long discontinued.

4. In addition to the water in the boiler, or to the feed water entering it, of chemical agents intended to render the less soluble salts in the water more soluble, and therefore less capable of forming deposits.

Very many of the nostrums that have from time to time been patented with this alleged object, have been incapable of any such action. They have often been educts of chemical or other manufactures, sought to be profitably got rid of, and not unfrequently of a character likely to be highly prejudicial to iron boilers. Thus soluble salts of arsenic and copper have been sold for this purpose. The chief agents that have been proposed with intelligent views, however, have been hydrochloric acid, more or less diluted; chloride of ammonia (sal ammonias), which constituted the matter of Ritterbandt's patent of 1850 or 1851; and chloride of calcium (an educt of many chemical manufactures). None of these are particularly effectual. Hydrochloric acid is a perilous addition to any iron boiler, as a very slight excess, when continued, will remove a large proportion of the thickness of the shell of the boiler in solution, as chloride of iron.

Sal ammoniac and other soluble chlorides are not free from this risk (for in presence of organic vegetable matter, iron is capable of decomposing slowly even common salt, and by a remarkable train of decomposition producing carbonate of soda, and evolution of free chlorine, which in turn re-acts upon the iron), and none of these agents have any advantageous action upon water rich in sulphate of lime.

Alkaline solutions, carbonate of soda, and caustic soda, have also been proposed, on the ground of their presence rendering the difficultly soluble salts of lime more soluble; but their action in this way is not marked, and the fact in practice is, that the alkaline water is carried up, more or less, with the steam into the pipes and engines, &c., and acts upon all flanges, joints, packings, paint, &c., as a destructive agent. Besides these, tan-pit liquor, decoction of oak bark, catechu, and various other astringent substances, have been strongly recommended by their several proposers; and perhaps strangest of all, dyewoods, and various vegetable coloring matters, constituted the sub-

ject of a patent of 1838,—of all of which we may safely say, that any other “chip in the porridge” would have been quite as useful.

Lastly, we arrive at the methods that have been proposed or adopted for mitigating or preventing deposit in marine boilers working with sea water.

In order of time, the first of these was the very primitive one of “blowing off,” that is to say, that the sailing engineer, at stated intervals fixed by experience, permitted the feed pumps to work an excess of feed water into the boilers, and then blew off at the sea-cocks fixed into the bottom parts of the boilers, thus removing at such operation some of the muddy deposit of saline matter at the bottom cells of the boiler, and with it some of the denser and more concentrated brine. Occasionally the order of the process was reversed, the blowing off preceding the feed in excess of the average consumption of water in steam, but with the danger of laying bare some of the flue plates when the water was thus lowered. However, like every “rule of thumb” method, and in common with all dependent upon personal care and continuous attendance, this was often perilously neglected; and in my own early practice as a mechanical engineer, I have known the London steam ships come into the port of Dublin with every “pocket” or side chamber, beside the furnaces of their boilers, choked up with one solid mass of salt, that could only be removed by cutting the side plates out and replacing them.

The inventions of Hall and others for providing marine engines with surface condensation, and hence working with fresh water only, the same water being evaporated over and over again, had amongst other objects in view the relief of this great evil; and it is now highly probable that eventually this form of engine will be made fully available, and will displace the use of feeding with sea water.

They failed at first, however, and the invention and perfecting of the boiler-feeding arrangements known as the Brine Pump, and of the salinometer, displaced in all well provided steamships the old system of blowing off.

The brine pump is an adjunct of the feed pump, and its function is to remove at each stroke of the engine a determinate volume of the water, withdrawn from that part of the boiler supposed to be most highly concentrated as a saline solution, while the feed pump supplies in its place a larger determinate volume of sea water in its natural state. The cold sea water to be pumped into the boiler is caused to pass through tubes immersed in the boiling saline liquid, being pumped out by the brine pump, and robbing the latter of some of its heat, economizes part of the fuel that would be otherwise wasted.

The salinometer (one of the earliest promoters, if not proposers, of which was Mr. Scott Russell) is in fact an areometer or hydrometer, by which the specific gravity of the liquid within the boiler, and at various levels, may be tested. There are various constructions, some always presenting indications, more or less exact, of the density of the fluid actually within the boiler, others requiring a certain volume of the hot liquid to be drawn off for trial—all depend

upon the common principle of the areometer, the floating or not of bodies of known density immersed in the liquid, with adjuncts for correction as to temperature, &c.

The brine pump is often used without the salinometer—still oftener with it, but independently of its necessary control. But in the most complete arrangements the salinometer itself is contrived so as to regulate the proportion between the volume of water withdrawn and that needed to be supplied by the feed pump.

This was done on board the *Don Juan*, as an early example by the salinometer (in this case a large copper sphere, with considerable buoyancy) acting directly upon the valves of the brine pumps and feed pumps. A want of sufficient mechanical power for complete and trustworthy control was, however, I believe, always found; and a much better arrangement, although one that I am not aware has ever been before proposed or tried, would appear to be the adaptation to this use of Dr. Ure's thermostat—making the *temperature only* of the fluid in the boiler, or rather coming through the brine pump out of it, the rule as to saturation, and causing the powerful flexure of the thermostat bars (which may be quite immersed within the boiler or its pipes) to act directly upon the valves regulating the supply.

It scarcely needs pointing out that no chemical, or other agents introducible to marine boilers, are capable of producing the slightest practical effect upon the enormous volume of water evaporated, and of saline matter in a state of deposit.

If the boiler contains 100 parts of sea water, and the parts evaporated for steam in a given time be  $= s$ , and if  $n$  be = the volume pumped out in order to preserve the state of saline concentration constant at  $a$ , = (a fraction) parts of solid saline matter, then, as there is 3 per cent. of saline matter in sea water (in round numbers)—when

$$3(s + n) = an.$$

The amount of saline matter entering the boiler by the feed pump and removed by the brine pump will be equal; and in this case the brine pump must remove

$$n = \frac{3 \cdot s}{a - 3} \text{ volumes.}$$

If  $a = 30$ , which is the saturated point for common salt — one-ninth of the feed water must be removed by the brine pump, and as  $\frac{1^n}{6}$ , the

fuel that will convert water into steam from a given temperature, will bring it to  $212^\circ$ , the loss of fuel by this inward influx of cold water to the boiler, and removal of boiling water, will be—

$$\frac{1^n}{6} + \frac{1^n}{9} = \frac{1^n}{54} \text{ of the whole quantity.}$$

assuming that none of the heat were returned to the boiler by conduction, between the issuing and entering fluids, as explained.

This somewhat crude view of this part of our subject will serve to illustrate the main question, to the more complete solution of which M. Couste's Memoir is dedicated.

In concluding this paper we may notice the improved salinometer of Long, which is much used in the steamships of the United States.

These instruments possess many advantages over those hitherto used.

They are *constantly in action*, and the density of the water may at any moment be read off; while the engineer *cannot be scalded, nor the hygrometer broken*, as is so often the case with the ordinary instrument.

The Committee of the Franklin Institute advise the "more general use of this valuable gauge, which ought not to be neglected on any boilers using salt water, and they commend it to the notice of all engaged in the management of such boilers." By its use a great saving of boiler and fuel is effected. See *Journal of Franklin Institute*, February, 1860, page 141.

### On Bessemer's Iron and Steel.

From the London Mechanic's Magazine, Sept., 1862.

Among the treasures of the Eastern Transept it would be unfair to omit noticing one of the most conspicuous, and, in some senses, one of the most important, trophies, namely, that of Mr. Bessemer. The taste which induced that gentleman to select as the medium for exhibiting specimens of his iron and steel, a polished mahogany stand, more in keeping with the fitments of a modern gin palace than appropriate to the use to which it is applied, may be questioned; but there can be no question about the value of the materials which the stand serves to display. In every variety of form, and in every process of its manufacture, the Bessemer iron and steel are shown in the Eastern Transept, and there adaptability to innumerable purposes is developed. It is not necessary here to enumerate the articles exhibited, nor to enter into the particulars of the remarkable and yet simple processes by which the conversion of crude iron into steel of the Bessemer kind is effected. It may be stated, nevertheless, that many and severe were the testings to which the substance was exposed, before it was admitted into the favor of those who were predisposed to the use of steel produced by the old, and time-honored system. The extreme toughness of the Bessemer iron was proved by the bending of a cold bar of 3 ins. square, under the hammer, and into a close fold, without the smallest perceptible rupture of the metal at any part; and the bar was thus extended on the outside of the bend from 12 ins. to  $16\frac{3}{4}$  ins., and was pressed on the inside from 12 ins. to  $7\frac{1}{4}$  ins., thus showing a difference in length of  $9\frac{1}{2}$  ins. between what, before bending, were the two parallel sides of a bar 3 ins. square. Again, an iron cable, consisting of four strands of round iron  $1\frac{1}{2}$  ins. in diameter, was, while cold, so closely twisted as to cause the strands at the point of contact to be-

come permanently embedded into each other. Each of these strands had become elongated to  $12\frac{1}{2}$  ins. in a length of 4 ft., and had diminished one-tenth of an inch in diameter throughout their whole length.

Steel bars, of 2 ins. square and 2 ft. 6 ins. in length, were twisted cold into a spiral, the angles of which were about  $45^{\circ}$ ; and some round bars, 2 ins. in diameter, were bent cold under the hammer, into the form of an ordinary horse-shoe magnet, the outside of the bend measuring 5 ins. more than the inside. The steel and iron boiler plates, left without shearing, and with their ends bent over cold, afforded ample evidence, too, of the extreme tenacity and toughness of the metal; while the clear, even surface of railway axles and pieces of malleable iron ordnance, were examples of the perfect freedom from cracks, flaws, or hard veins. The tensile strength of this metal was not less remarkable. The several samples of steel tested in the Proving Machine at Woolwich Arsenal bore, according to the reports of Colonel Eardley Wilmot, R. A., a strain varying from 150,000 lbs. to 160,900 lbs. on the square inch. Four samples of iron boiler-plate similarly tested, bore from 68,314 lbs. to 73,100 lbs.; while, according to the published experiments of Mr. W. Fairbairn, Staffordshire plates bore only 45,000 lbs., and Low Moor and Bowling plates a mean of 57,120 lbs. per square inch. Of course, the cost of production of the materials was considerably less than that of the plates put into competition with Mr. Bessemer's; and here another advantage of no slight consequence is evident.

*Specification of a patent granted to WILLIAM MATTIEU WILLIAMS, for an improvement in treating coal and other bituminous minerals and peat, in order to obtain solid and liquid hydro-carbons therefrom, and in apparatus to be used for that purpose.*—(Patent dated 21st December, 1861.)

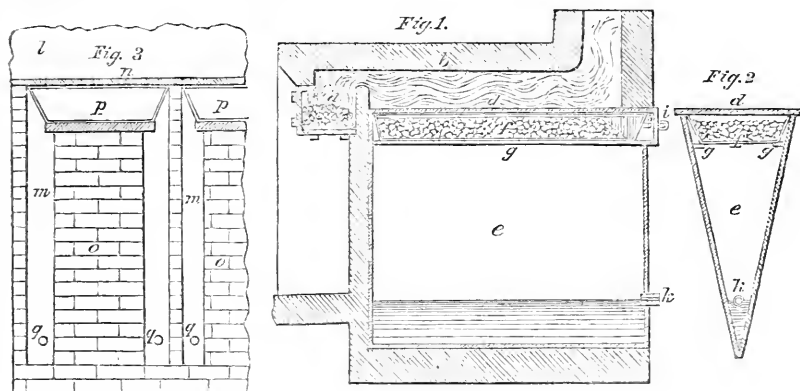
From Newton's London Journal of Arts, September 1862.

The object of this invention is so to treat coal and other bituminous minerals, and peat, by the distillatory process, as to increase the solid and liquid or more valuable products, in proportion to the gaseous or less valuable products. In the distillation of coal, it is found that the gaseous products of the distillation are mainly or largely produced by the decomposition of the vapors of the solid and liquid products; the decomposition being affected by such vapors coming in contact with portions of the retort or its contents, heated to a higher temperature than that at which the vapors are liberated from the coal. By conducting the distillation in the manner and by means of the apparatus hereafter described, the overheating of the condensible products, first volatilized from the coal, is prevented, and thereby a larger yield of the condensible products is secured.

The apparatus used for treating coal and other bituminous minerals, and peat, in order to obtain solid and liquid hydro-carbons therefrom, is shown in diagram; fig. 1 being a vertical longitudinal section of the retort, set in a reverberatory furnace, and fig. 2 a cross vertical



section. The flame and products of combustion from the fire in the fire-place *a*, pass along the reverberatory arch *b*, into the chimney or flue *c*. The heat is reverberated downwards upon the bed *d*, of the furnace, which bed *d*, constitutes the top of the retort *e*, or a casing immediately above the top of the retort. The lower part of the retort *e*, tapers or contracts, as seen in fig. 2. Where the vessel is short, it is made taper on all sides—that is, it is made of the figure of an inverted cone or pyramid, but when much longer than it is broad, the tapering is confined to the inclination of the two longer sides, as represented in figs. 1 and 2.



The coal or other matter to be treated is placed in the cage or tray *f*, which rests upon the projections *g*. The sides of the tray *f*, are perforated, or are made of bars. The trays may be introduced into, and withdrawn out of, the distillatory vessel *e*, in a horizontal direction, at an opening in the side of the vessel at *h*, which opening is closed after the introduction of the charge, by means of a door *i*. The plate *d*, which constitutes the bed of the furnace and the top of the distillatory vessel, may be protected from injury by the fire, by a layer of thin fire-tiles or powdered clay or sand, or a mixture of clay and sand. The fire of the furnace *a*, plays upon and heats the top of the vessel *e*, and the heat from the heated top radiates downwards upon the contents of the tray *f*, and liberates volatile hydro-carbons therefrom. The vapors produced pass out between the bars constituting the sides of the tray *f*, or through perforations in its sides and bottom, and descend to the lower part of the distillatory vessel, from which the condensed and uncondensed portions pass by a pipe *k*, fixed nearly at the bottom of the vessel *e*. A small quantity of water, which is formed or volatilized with the hydro-carbons, condenses and occupies the bottom of the vessel *e*, and may be let off by a stop-cock fixed at the lowest point of the vessel *e*.

In carrying this invention into effect on a large scale, several retorts or distillatory vessels are employed, arranged side by side in the same furnace. In this case, the retorts are placed across the reverberatory arch of the furnace, as represented in the vertical section, fig. 3, which

is taken along the middle of the reverberatory arch *l*. Each of the retorts or distillatory vessels consists of a chamber *m*, the sides and bottom of which may be made of iron or of brickwork. The top of the chambers consists of a plate, or series of plates, of cast or wrought iron *n*, on which the heat of the furnace is reverberated by the reverberatory arch or flue *l*. In the middle of each retort or distillatory vessel is a wall or support of brickwork *o*, running from end to end of the vessel. The said walls or supports *o*, in each vessel, support the trays *p*, containing the material to be operated upon. The trays are introduced into the retorts *m*, at openings at the end of the vessels, similar to the openings hereinbefore described and represented in fig. 1, or those employed in ordinary gas retorts. Pipes at *q*, conduct the condensed and uncondensed products of distillation away from the distillatory vessels into a receptacle, where the condensation of the condensible products may be completed.

The distillation may either be conducted at atmospheric pressure, or at a greater or less pressure than that of the atmosphere. In the first case, the terminal pipe of the retort is open, and the condensed products run therefrom. In the second case, the bottom of the pipe is closed by a valve, weighted, so as to give the required pressure. In the last case, the terminal pipe of the retort is connected with an exhausting pump or other exhausting apparatus, worked by steam or other power.

The patentee claims, "First,—the improvement hereinbefore described, in treating coal and other bituminous minerals, and peat, in order to obtain solid and liquid hydro-carbons therefrom—that is to say, subjecting these substances to a distillatory process so conducted that the volatile products produced pass rapidly downwards from the heated part of the apparatus, so as not again to be exposed to a temperature equal to that at which they were produced. Secondly,—the improvement in apparatus for treating coal and other bituminous minerals, and peat, in order to obtain solid and liquid hydro-carbons therefrom, hereinbefore described and illustrated—that is to say, constructing and arranging the retorts or distillatory vessels so that heat is applied at the top of the said vessels, and the volatile products conducted, by a descending motion, from the heated parts of the said apparatus."

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#### *Improvement in Tanning.*

The fresh bark is to be ground and introduced into a cask; a quantity of water sufficient to cover it is introduced, and the cask is then closed hermetically to prevent the action of the atmospheric air. It is suffered to remain for some weeks in order to allow the soluble matters to dissolve, and is then filtered to free it from the refuse bark. This liquid, when exposed to a gentle heat, enters into alcoholic fermentation, and will mark  $1^{\circ}$  or  $2^{\circ}$  on the alcoholometer. If a skin be introduced into this solution, it tans very quickly, but becomes hard and horny because the liquid is too much concentrat-

ed. If on the contrary it be diluted with water, excellent results are obtained. The hides thus tanned are more pliable and the grain is closer than in those tanned by the common method. The same quantity of bark, moreover, produces more tanning material, in this new method.

The bark should not be boiled with the water; for the boiling coagulates the albumenoid matters, which excite the fermentation. The author has satisfied himself by trial, that the liquid which has undergone only the alcoholic fermentation gives better results than that which has become acid.

*Cosmos.*

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### On the Exhalations from Wood.

From the London Builder, No. 1018.

Everything in London continues to assume more and more gigantic proportions. The quantity of lucifer matches for one day's metropolitan consumption has often excited surprise: it is daily on the increase, as is also the quantity of firewood, which is enormous. Besides the parts of decayed merchant vessels, and other battered "old hulks;" the timbers and boards of demolished buildings which cannot be again worked into new ones, the salvage from fires, &c.; there are immense quantities of pine wood brought from over the sea as mere firewood. It is cut into pieces of about 3 feet in length, and of convenient thickness; so that, by means of steam-sawing machinery, they can readily be cut into the usual length of the bundles of firewood sold in the shops: they are then chopped, sorted, and tied up by boys, ready for sale.

During the summer months, the planks of wood, as they are unshipped, are brought in barges to convenient wharfs along the margin of the canals; and are stacked until needed for use. Some of these collections of firewood are cleverly built up, and are of gigantic proportions: one or two of these may be seen in the wharf of Mr. Humphries, in the York-road: one stack is at least 50 feet high, and is ingeniously constructed, so that the chief bulk of the materials is sheltered from the weather, and allowed to dry. The *architect* of this wooden work, with an eye towards effect, has caused it to assume something of the appearance of a military fortress, by leaving holes for imitation cannon, which point in a threatening manner towards the road. The building up of these towers, as barge after barge-load of timber arrives, gives employment to a large number of youths and boys; and, during the whole year, the chopping and preparation of the firewood—not only here, but also in other parts of London—keeps busy some hundreds of boys, many of them connected with the reformatory and other schools.

The manufacturing of the patent firewood—an invention by which the wood is cut into very small pieces, and joined together in a circular form by means of resin—is chiefly managed by boys; and it is astonishing to see the rapidity with which the process is carried forward by the nimble fingers and the machinery employed on the mate-

rial, and the quantities of this prepared firewood which are constantly passed into the London market.

There are other large stores of wood for building and other purposes along the sides of the canal; and, as space is valuable, these also are built up to a great height, and the planks are so arranged that they are but little exposed to the wet, while the air is allowed to ventilate through all parts.

We have just now more particularly mentioned these collections of timber for the purpose of directing attention to a peculiarity connected with them. Often, in certain neighborhoods, especially if the place be closely confined, the writer has noticed a smell which he had attributed to imperfect drainage; but finding, in one or two instances, that there were no derangements of this kind to be complained of, he looked for other reasons, and found that there were stores, either greater or smaller, of green and other wood, in the localities where this peculiar smell was to be met with; and he has since found that from these collections of wood a considerable quantity of gas is thrown off, which pervades the atmosphere to some distance around. We do not say anything just now about the unwholesomeness of this, but simply mention the fact, so that it may explain a circumstance which might otherwise puzzle the sanitary inquirer.

### *Electric-Express.*

M. Bonelli, the re-inventor of Bain's (Bakewell's) copying telegraph, suggests a new application of electricity for the transmission of letters, light parcels, &c. A series of coils of insulated wire are adjusted along the route, and through them runs a pair of rails upon which travels the wagon which carries the despatch-box. This wagon also carries an electric battery, and the end of the coils are so adjusted that the battery connexion is made, by means of the wheels and rails, through the coil which it is just about to enter. As the wagon is of sheet-iron, it will be attracted to the centre of the coil, and the momentum which it acquires will carry it far enough to make the connexion through the next coil, when the impulse is renewed.

This contrivance will make a very pretty philosophical toy, or piece of illustrative apparatus; but can it be economically applied on a practical scale?

*Cosmos.*

### *Ventilators or Valves.*

From the London Builder, No. 1020.

Letters patent have been taken out by Mr. Neil McHaffie, 16 Summer-street, Mile-end, Glasgow, for the invention of "improvements in ventilators or valves for regulating the passage of air or other fluids, whether of a gaseous or liquid form." The specification thus describes Mr. McHaffie's invention:—"According to my invention, when applying a ventilator or valve for admission of external air, I

cause the current of air entering to impinge on a surface so arranged that, when the current of air exceeds the velocity considered desirable, the surface may be able to yield to it, and on yielding may close or partially close the valve. When the force of the current diminishes the valve again opens, it being so weighted as always to tend to do so. The arrangement I prefer consists of an inlet valve turning on an axis at the centre of its width. This valve is connected by a suitable connecting-rod to a surface mounted on a horizontal axis at or near its lower end. The said surface is weighted beneath the axis, so that it tends always to assume a vertical position. It is placed at a short distance from the before-mentioned valve, within a trunk or passage, which obliges the air or other fluid entering by the said valve to pass the before-mentioned surface. This current of air or other fluid throws the surface into a more or less inclined position, according to its strength; and the more inclined the position of the surface, the more nearly will the valve be closed. For the passage of liquids this last-mentioned surface should be mounted on a horizontal axis; but instead of being at or near its lower, it should be at or near its upper extremity, on account of the greater density of the fluid, the passage of which is sought to be regulated."

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### *Texture of Copper.*

M. U. Vivian showed last year that manufactured copper always has a porous and cellular texture; whilst native copper is always crystalline. Now he proves that the native copper from Lake Superior is neither crystalline nor cellular, but dense, ductile, and fibrous, as though it had been violently compressed when cold. When melted it however takes the structure of all manufactured copper.—*Cosmos*.

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### *Experiments on Steel Wire-Rope.*

From the Lond. Mining Journal, No. 1419.

At the Liverpool Corporation Testing-Works, on Tuesday, a number of gentlemen interested in the subject assembled for ascertaining the superiority, if any, of steel wire-rope, as compared with iron wire-rope. Experiments had been previously made upon bright steel wire, which, being liable to rust, it was now thought desirable to know if the strength would in any degree be impaired by the wire undergoing the process of galvanizing; and it was chiefly for this reason the experiments were made, the samples being ropes made of steel wire galvanized. The results obtained were—Galvanized steel, 2 in., broke at 13 tons 15 cwts.; Admiralty test for iron wire, 4 tons 6 cwts.; galvanized steel, 2½ in., broke at 19 tons 10 cwts.; iron wire, Admiralty test, 7 tons 8 cwts.; galvanized steel, 4 in., broke at 41 tons 5 cwts.; iron wire, Admiralty test, 19 tons 6 cwts. Two pieces of 2½ in., of fine bright steel, similar to that used for musical instruments, broke, one at 24 tons 5 cwts., the other at 26 tons 5 cwts. Thus, by the confirmation of two separate tests, we are assured that steel possesses

all the qualities suitable for its being used for all purposes, whether in mines or elsewhere, where great strength is required. Indeed, for strength, lightness, toughness, and elasticity, it is unsurpassed, and it is calculated that while the expense is little more than that of common iron, by the substitution of steel Messrs. Garnock, Bibby and Co. will be enabled to save about 4 tons in the weight of the rigging of a single ship.

*New Method of Organic Analysis.* By M. MAUMENÉ.

In our present processes of organic analysis, there is no direct means of determining the quantity of oxygen, this important element being estimated simply by the loss, or difference between the sum of the weights of the other elements computed, and the original weight of the body—of course every error committed in the estimation of the carbon, hydrogen, and nitrogen is accumulated upon the determination of the oxygen. Hence, in great part, the want of agreement as to the percentage of this substance among analysts. M. Maumené proposes to determine the oxygen by using the oxide of lead or litharge mixed with one-quarter of its weight of phosphate of lime to prevent it from fusing. We then obtain, by the reduction of the litharge, a button of metallic lead which may be accurately weighed. This gives

us a third equation of the analysis, viz:  $\text{Carbon} = \frac{3}{11}$  of the carbonic

acid;  $\text{Hydrogen} = \frac{1}{9}$  water;  $\text{Oxygen} = \frac{8}{9}$  water +  $\frac{8}{11}$  carbonic

acid —  $\frac{8}{103.5}$  lead, and the values determined from these three equa-

tions must satisfy the original equation. *Weight used* = Carbon + Hydrogen + Oxygen. *Acad. Sciences, Paris, Sept., 1862.*

*Testing the purity of the Atmosphere.*

From the London Builder, No. 1029.

Dr. Angus Smith has shown, by his process of testing the purity of the atmosphere, that a given amount of permanganate solution is decomposed by different volumes of air, according to its state of purity. The numbers below given show the volume of air capable of decomposing an amount of the solution of the permanganate,—the same in every case. The figures, therefore, represent the proportionate purity of the air. The highest numbers represent the purest.

*Manchester.*

	Cubic Inches.
Air at All-Saints, inside my laboratory, . . . . .	72,000
Front of the house, . . . . .	74,000 to 76,000
Bed-room, looking to the back, . . . . .	64,000
Same room in the morning, after having been slept in, . . . . .	56,000
Bank of the Medlock, behind dirty houses, . . . . .	44,000
High ground, thirty miles from Manchester, . . . . .	176,000 to 209,000
Closely-packed railway-carriage, . . . . .	8,000
When the strong smell of a sewer entered my laboratory, . . . . .	8,000

*On a Green Color which may be Employed in Confectionery.*

From the London Chemical News, No. 142.

The finest green color is formed, as is known, from preparations of copper and arsenic; that of which the formula is here given is devoid of danger, and may replace it. To obtain it, infuse for twenty-four hours 0.32 grammes of saffron in 7 grammes of distilled water. Then take 0.26 grammes of carmine of indigo, and infuse it in the same manner in 15.6 grammes of distilled water. Then mix the two liquids together, and a very beautiful green color is obtained, which may be employed for coloring an immense quantity of sweetmeats (10 parts of this solution will color 1000 parts of sugar of a very beautiful green). This color may be preserved for a long time, either by evaporating the liquid to dryness or by converting it into a syrup.—*Journal de Pharmacie et de Chimie*, xli. 286.

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*Glass Blowing.*

A Belgian glass-blower, M. Emile Lefevre-Moran, attached to the glass-works of Lefevre & Co., at Lodelingart, has just blown two bottles containing each 62½ gallons and weighing 50 pounds. The largest heretofore blown did not contain more than 32½ gallons.—*Cosmos*.

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*Parkesine.*

From the Lond. Chemical News, No. 140.

A number of pretty and useful articles, formed of a material which the inventor, Mr. Parkes, has named after himself, are exhibited in Case 1112, Class IV. The basis of this material is the mixture of collodion and castor oil, with which our medical and pharmaceutical readers are well acquainted. With this compound the inventor mixes coloring-matters, resins, gums, and earthy matters, according as he wishes, for a plastic, flexible, or hard material, out of which to form medallions, combs, or knife-handles, and the like. The specimens exhibited look pretty as well as useful, and are no doubt durable as long as they are kept out of the fire. A wide field is open for applications of the substance, and Mr. Parkes should get it into the market, and ascertain how far it can compete with similar articles having india-rubber for their basis.

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FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, Dec. 18, 1862.*

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society and the Institute of Actuaries, London, and the Literary and Philosophical Society, Manchester, England; Thomas Oldham,

LL.D., Superintendent of the Geological Survey of India, Calcutta, India; from Hon. Wm. D. Kelley, Frederick Emmerick, Esq., and the Agricultural Department, Washington, D. C.; S. Stockton White, Esq., Prof. John F. Frazer, Prof. John C. Cresson, Captain S. W. Dewey, and the American Philosophical Society, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement of the receipts and payments for the month of November was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (9) were proposed, and the candidates (15) proposed at the last meeting were duly elected.

Nominations were made for Officers, Managers, and Auditors of the Institute for the ensuing year.

Mr. Thomas Stewart exhibited an Anti-friction Valve patented by him, and stated that the object of the invention is to obtain an Anti-friction Valve that will not require attention to keep it in working order, nor that precision of adjustment which balanced valves require—the steam operating on the mechanism performs this office with unerring precision.

To accomplish this object, the inventor uses the following arrangement:—First, the ordinary slide valve is made with the back planed true with the face; on this there is a frame made to work steam-tight, covering a part of the valve equal to the area of the ports in the valve-seat; on the other side of this frame there is secured, steam-tight, a flexible diaphragm, which shuts the steam off from the inside of the frame, relieving the valve of so much of the pressure of the steam; the pressure now being exerted on the diaphragm, so much of the centre of the diaphragm as is equal to the area of the frame in contact with the valve, is suspended to a cross-piece resting on two projections on the sides of the steam chest, thus relieving the valve of all unnecessary pressure; at the same time the flexibility of the diaphragm allows the balance frame, by a very slight pressure of steam, to keep the frame in close steam-tight contact with the valve, and also allow the valve to move freely under it.

Mr. Thomas Shaw exhibited a valve designed by him and patented August 9th, 1862. It is intended to relieve feed pumps of the air or vapor that accumulates whilst they are not working. It consists of a chamber containing a thin gum-valve closing upon a metal seat and opening outward. A stop-cock is interposed between this valve and the pump to close the communication after the air or vapor is expelled, and prevent the escape of the water.

Mr. John Sloan exhibited a number of inside soles for shoes, intended to keep moisture from contact with the feet. They are composed of two thicknesses of wood, with a thin metal plate of brass between, the whole united by eyelets, which also serve for circulation of air.



*A Comparison of some of the Meteorological Phenomena of Nov., 1862, with those of Nov., 1861, and of the same month for TWELVE years, at Philadelphia, Pa.*  
 Barometer 60 feet above mean tide in the Delaware River. Latitude  $39^{\circ} 57\frac{1}{2}'$  N.; Longitude  $75^{\circ} 10\frac{1}{2}'$  W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	November, 1862.	November, 1861.	November, 12 Years.
Thermometer—Highest degree, .	71·00°	63·50°	80·0°
“ “ date, .	2d	3d.	1st, 1860.
“ Warmest day—Mean, .	61·67	58·70	72·30
“ “ date, .	2d	2d.	9th, 1857.
“ Lowest degree, .	27·00	29·00	16·00
“ “ date, .	7th and 8th.	25th.	25th, 1860.
“ Coldest day—Mean, .	30·50	35·50	23·30
“ “ date, .	7th.	25th.	25th, 1860.
“ Mean daily oscillation, .	13·40	13·08	13·38
“ “ range, .	5·94	4·11	5·65
“ Means at 7 A. M., .	40·67	39·85	41·06
“ “ 2 P. M., .	48·18	48·73	50·18
“ “ 9 P. M., .	43·25	43·25	44·25
“ “ for the Month, .	44·03	43·94	45·16
Barometer—Highest—Inches, .	30·555 in.	30·109 in.	29·661 in.
“ “ date, .	16th.	1st.	12th, 1851.
“ Greatest mean daily press., .	30·509	30·075	30·520
“ “ date, .	16th.	1st.	12th, 1851.
“ Lowest—Inches, .	29·380	29·213	29·117
“ “ date, .	20th.	6th.	19th, 1857.
“ Least mean daily pressure, .	29·467	29·359	29·255
“ “ date, .	20th.	6th.	19th, 1857.
“ Mean daily range, .	·159	·179	·184
“ Means at 7 A. M., .	29·877	29·793	29·918
“ “ 2 P. M., .	29·823	29·736	29·877
“ “ 9 P. M., .	29·870	29·785	29·905
“ “ for the Month, .	29·857	29·771	29·900
Force of Vapor—Greatest—Inches, .	·548 in.	·523 in.	·532 in.
“ “ date, .	20th.	2d.	8th, 1857.
“ “ Least—Inches, .	·106	·099	·055
“ “ date, .	16th.	19th	25th, 1857.
“ “ Means at 7 A. M., .	·213	·199	·227
“ “ “ 2 P. M., .	·228	·210	·231
“ “ “ 9 P. M., .	·224	·206	·234
“ “ for the month, .	·222	·205	·231
Relative Humidity—Greatest per cent., .	100· per ct.	96·0 per ct.	100· per ct.
“ “ date, .	7th.	23d.	6th, '52; 21st, '56.
“ “ Least per cent, .	37·	32·0	26·0
“ “ date, .	13th.	19th.	27th, 1857.
“ “ Means at 7 A. M., .	79·4	78·2	77·8
“ “ “ 2 P. M., .	64·5	58·1	59·5
“ “ “ 9 P. M., .	75·1	70·5	74·2
“ “ for the month, .	73·0	68·9	70·5
Clouds—Number of Clear days,* .	8	9	8·7
“ “ Cloudy days, .	22	21	21·3
“ “ Means of sky cov'd at 7 A. M., .	64 per ct.	51·7 per ct.	60·1 per ct.
“ “ “ “ 2 P. M., .	64·3	66·7	60·5
“ “ “ “ 9 P. M., .	63·7	52·3	52·6
“ “ “ for the month, .	64·0	56·9	57·7
Rain and melted Snow—Amount .	4·455 in.	4·613 in.	3·822 in.
No. of days on which Rain or Snow fell, .	15·	11·	10·8
Prevailing Winds, . . .	N. 79° 0' W. ·237	N. 68° 12' W. ·324	N. 67° 43' W. ·254

\* Less than one-third covered at the hours of observation.

*A Comparison of the AUTUMN of 1862, with that of 1861, and of the same season for TWELVE years, at Philadelphia, Pa. Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N. Longitude 75° 10½' W. from Greenwich.*

	Autumn, 1862.	Autumn, 1861.	Autumn. 12 Years.
Thermometer.—Highest degree, .	87·00°	88·0°	95·00°
“ “ date, .	8th Sept.	6th Oct.	Sept. 12, 1851.
“ Warmest day—Mean,	77·33	78·33	85·20
“ “ date, .	8th Sept.	6th Oct.	Sept. 6, 1854.
“ Lowest degree, .	27·00	29·00	16·00
“ “ date, .	7th & 8th Nov.	25th Nov.	Nov. 25, 1860.
“ Coldest day—Mean,	30·50	35·50	23·30
“ “ date, .	7th Nov.	25th Nov.	Nov. 25, 1860.
“ Mean daily oscillation,	14·98	15·75	15·36
“ “ “ range,	5·24	4·60	5·30
“ Means at 7 A. M.,	52·30	52·18	51·70
“ “ 2 P. M.,	62·83	63·36	62·87
“ “ 9 P. M.,	55·93	56·22	55·53
“ “ for the Autumn,	57·02	57·25	56·70
Barometer.—Highest—Inches, .	30·555 in.	30·452 in.	30·661 in.
“ “ date, .	16th Nov.	25th Oct.	Nov. 12, 1851.
“ Greatest daily mean press.,	30·509	30·378	30·520
“ “ date, .	16th Nov.	25th Oct.	Nov. 12, 1851.
“ Lowest, Inches, .	29·307	29·213	29·012
“ “ date, .	27th Oct.	6th Nov.	Oct. 26, 1857.
“ Least daily mean pressure,	29·467	29·359	29·059
“ “ date, .	20th Nov.	6th Nov.	Oct. 26, 1857.
“ Mean daily range, .	·146	·163	·151
“ Means at 7 A. M.,	29·874	29·897	29·941
“ “ 2 P. M., .	29·831	29·847	29·899
“ “ 9 P. M.,	29·868	29·878	29·922
“ “ for the Autumn,	29·858	29·874	29·921
Force of Vapor.—Greatest—Inches,	·833 in.	·770 in.	·991 in.
“ “ “ date, .	12th Sept.	15th Sept.	Sept. 6, 1854.
“ “ Least—Inches,	·106	·099	·055
“ “ “ date, .	16th Nov.	19th Nov.	Nov. 25, 1857.
“ “ Means at 7 A. M.,	·339	·349	·340
“ “ “ 2 P. M.,	·365	·380	·360
“ “ “ 9 P. M.,	·369	·383	·360
“ “ “ for the Autumn,	·358	·371	·353
Relative Humidity.—Greatest per cent.,	100· per ct.	97· per ct.	100· per ct.
“ “ “ date, .	7th Nov.	Sept. 20; Oct. 19.	Often.
“ “ Least per cent,	32·0	32·0	23·0
“ “ “ date, .	3d Sept.	19th Nov.	Oct. 21, 1859.
“ “ Means at 7 A. M.,	78·7	80·8	78·4
“ “ “ 2 P. M.,	59·4	59·2	57·4
“ “ “ 9 P. M.,	74·7	75·3	74·2
“ “ “ for the Autumn	70·9	71·8	70·0
Clouds—Number of Clear days,*	31 days.	29 days.	29·7 days.
“ “ Cloudy days,	60 days.	62 days.	61·3 days.
“ Means of sky cov'd at 7 A. M.,	58·8 per ct.	61·8 per ct.	57·3 per ct.
“ “ “ 2 P. M.,	55·3	63·0	55·3
“ “ “ 9 P. M.,	52·8	46·1	42·5
“ “ “ for the Autumn	55·6	57·0	51·7
Rain and melted Snow—Amount,	14·897 in.	13·186 in.	10·847 in.
No. of days on which Rain or Snow fell,	32·	27·	27·5
Prevailing winds, . . .	N 64° 56' W 140	N 76° 25' W 204	N 77° 3' W 228

\* Less than one-third covered at the hours of observation.

## PROMOTION OF THE MECHANIC ARTS.

CIVIL ENGINEERING.

From the Lond. Civ. Eng. and Arch. Jour., Sept., 1862.

## GIRDERS OF GREAT SPAN.

$$G = \frac{sk(w_2 + F)}{1 - sk} \quad . \quad . \quad . \quad . \quad (3)$$

We have now in the first place to determine the values to be assigned to  $F$  for given spans;  $F$  being the total dead weight of the portion of the complete structure required for one line of railway, exclusive of  $G$ , the weight of the bare girder.

The most anomalous part of the structure is that addition to the girders rendered necessary by their having to act in the secondary capacity of booms to the fabric, when engaged in resisting the lateral pressure of the wind; the webs in this action being represented by the strata of horizontal bracings.

Misled by the minuteness of this addition when the span is short, and a considerable width is given to an openwork structure, we spoke of it as of such moderate amount that it might generally be treated as covered by the value 3.5 taken for the factor of safety; in extreme

or peculiar cases alone a separate provision becoming necessary. Actual calculation has, however, pointed out to us that this addition becomes so very considerable as the spans increase, that, although doing so mars the simplicity of the investigation, we must make an independent allowance for it.

Notwithstanding this modification in our views, we still consider that the general factor of safety should be taken of a uniform value (3.5) for cases in which the dead weight amounts to more than a certain percentage (71.4) of the movable loading. Any apparent excess of strength that this may give for the girders of the longer spans, will probably be required to counteract the greater destructive effect of the wind, arising from the virtually increased suddenness of application, and the increased chance of the wind impulses corresponding with the oscillations of the structure.

The metal added to the girder, to resist the longitudinal stresses resulting from the lateral action of the wind, may for one double girder be represented by the letter *E*. This is generally, but not necessarily, incorporated with the booms of the girder. It is to be remembered that *E* is to be treated as part of *F*, not of *G*; *G* must be taken for the weight of those parts alone which are directly employed in supporting the whole weight and loading acting vertically.

The amount of *E* will vary so much with the nature of the structure, that any formula for it must be of limited applicability, and employed with caution; we shall endeavor, however, to arrive at one which will be suited to the general arrangement we have chosen for bringing out the comparisons, viz:—two double openwork girders placed 27 feet apart from centre to centre, prepared for the support of a double line of railway at the lower level.

The resistances to the wind will consist of that offered by the structure itself and that by the trains; estimating these by their amount per foot run of span, the latter will be constant, but the former will increase somewhat with the span the sum of these resistances, which we may denote by the letter *r*, and will be pretty accurately represented by this formula:

$$\left. \begin{array}{l} \text{Resistance to wind in} \\ \text{tons per foot run} \end{array} \right\} = r = \frac{1}{100} \sqrt{s} + \frac{1}{10} \quad . \quad . \quad (4)$$

The whole side pressure on the structure will be = *sr*, therefore the sum of the stresses induced in each girder at the midspan will be—

$$= sr \frac{s}{8 \times 27} = \frac{1}{216} s^2 r \quad . \quad . \quad . \quad (5)$$

This is to be distributed between the two booms of each girder, and as it may be either a tension or a compression, according to the direction of the wind, we must estimate the portion taken by the lower boom as a tension, and the portion taken by the upper boom as a compression. If the roadway be at the lower level, considerably more than the half will be brought upon the lower boom; but for our present purpose we do not need to determine the proportions in which it is dealt out to the booms, since to cover the expense of ma-

terial for joint-plates, loss by rivet holes, &c., we may take the same allowance of metal for the resistance of compressive and tensile stresses—say one inch for every four tons. The whole stress then divided by 4 gives us  $s^2r+864$  as the sum of the additions to be made to the sections of the booms of each girder at the midspan. Now the booms being otherwise strong at the extremities, we may calculate the additions made to the sections at other parts of the span as in exact proportion to the stresses; therefore the total increase of weight in the booms will be given by this formula,  $E$  being the increase of weight in tons for the whole of the double girder—

$$E = \frac{2}{3} s \times 0.0015 \times \frac{1}{864} s^2 r = \frac{s^3 r}{864000} \quad . \quad . \quad . \quad (6)$$

The following table will give an idea of the importance of these additions:—

TABLE I.

Span in feet.	$r$ , in tons.	Increase of section at the midspan in sq. inches.	Increase of weight or $E$ in tons.
100	200	2.31	0.23
200	211	11.11	2.22
300	273	28.11	8.40
400	300	55.55	22.22
500	324	93.72	46.86
600	345	143.7	86.22
700	365	207.0	144.90
800	383	283.6	226.88

*The Horizontal and Transverse Bracings.*—We have now to calculate the weight of these. The horizontal bracings may be arranged in two or more strata. When the number is more than two, that is when, besides the bracing at the top and bottom of the girder, one or more bracings at intermediate heights are introduced, part of the metal  $E$  treated of as above as generally incorporated with the booms must be detached therefrom, and affixed where the horizontal bracings join the web. The existence of intermediate strata will strengthen the struts of the web, but may occasion the consumption of some more material in the horizontal bracings themselves; which, however, will be compensated by a saving in the transverse bracings.

In the principal stratum of horizontal bracing, or that at the level of the roadway, some saving may be effected by making use of the transverse girders as struts.

In very many cases a considerable saving of material will arise from making the parts of a horizontal bracing *double-acting*, so that every part will be of use, on whichever side the wind may blow. This saving will become more significant the greater the stress to be conveyed, since the efficiency of the parts to act as struts becomes thereby greatly augmented. The saving on this account in large structures (the length of the parts being nearly constant) is so important that it may be looked upon as fully counterbalancing the increase in the value of  $r$ , as exhibited in Table I. We consequently find that a very simple formula will express with sufficient accuracy the weight

of the horizontal and transverse bracings, taken together and estimated very liberally.

$$\left. \begin{array}{l} \text{Weight of horizontal and transverse} \\ \text{bracings for each line of railway,} \end{array} \right\} = s^2 + 8000 \quad . \quad . \quad . \quad (7)$$

The results for various spans will be found in col. 3 of Table II.

*The Transverse Girders of the Roadway Platform.*—If these are made pretty deep, and placed, say 6 feet apart, we may take them with fastenings complete at 1·8 ton each; this is equivalent to 0·15 ton per foot run for each line of railway.

*The Planking, Longitudinal Bearers, &c., of Timber.*—We may take the united sectional area of these at 12 feet for the whole bridge, which with an allowance for fastenings, and a protecting coating of sand, &c., may be estimated as amounting to 0·15 ton per foot run for half the width of the bridge, or for one line of railway. The total roadway platform, &c., which constitutes the constant portion of F, may then be estimated as follows, for one line of railway, or per double girder.

Transverse girders . . . . .	0·15 per foot run.
Planking, balks, &c., . . . . .	0·15 "
Permanent way . . . . .	0·06 "
Handrail, . . . . .	0·01 "
<hr/>	
Total, . . . . .	0·37

Weight of roadway platform, permanent way, including safety rails, &c., and all other dead weight excepting G, E, and the horizontal and transverse bracings,

$$= s \times 0·37 \quad . \quad . \quad . \quad . \quad (8)$$

And therefore

$$F = E + \frac{s^2}{8000} + 0·37s \quad . \quad . \quad . \quad . \quad (9)$$

The following table exhibits some of the values in tons of F and its components.

Span.	E.	TABLE II.		Platform, &c.	F.
		H and T bracings.			
100 . . . . .	0·23	+	1·25	+	38·48
200 . . . . .	2·22	+	5·00	+	81·22
300 . . . . .	8·40	+	11·25	+	130·65
400 . . . . .	22·22	+	20·00	+	190·22
500 . . . . .	46·86	+	31·25	+	263·11
600 . . . . .	86·22	+	45·00	+	353·22
700 . . . . .	144·90	+	61·25	+	465·15
800 . . . . .	226·88	+	80·00	+	602·88

We now proceed to ascertain the values of  $k$  for various structures, treated with different values of the factor of safety.

Formula (2) gives us  $k = \frac{G}{ws}$ , wherein  $w$  represents the whole load

supported, and supposed to be uniformly distributed over the span.

Let us first take, as perhaps the simplest possible example, a solid rectangular bar of wrought iron; and let us assume that a bar one inch square placed on supports one foot asunder, becomes destroyed, for all practical purposes, by a central load equal to one ton, or two tons

spread uniformly over its length. Then calculating our elements for such a bar, we have  $G=0.0015$  tons,  $w=2.0015$  tons,  $s=1$ . And therefore

$$k_1 = \frac{.0015}{2.0015} = .000749$$

$$\text{And } k_{3.5} = 3\frac{1}{2}k_1 = .002622.$$

The ultimate span to which such a bar could be extended without breaking down under its own weight, supposing no lateral disturbing cause, such as the wind, to exist, would be  $=1 \div .000749 = 1335$  feet. And the utmost span to which, under similar circumstances, such a bar could be extended, so that the factor of safety should not descend below 3.5, would be

$$=1 \div .002622 = 381 \text{ feet.}$$

If the effects of the wind were introduced, these ultimate spans would undergo reductions according to the narrowness of the bars.

In the above example the span is twelve times the depth. To show, in a simple manner, the influence of the ratio of the depth to the span upon the value of  $k$ , let us take the rectangular bar of double the above depth. For a bar of 2 inches deep, say 2 inches wide, and 1 foot span, we have  $G=.006$ ,  $w$  or the distributed breaking weight  $= 2 \text{ tons} \times \text{breadth} \times \text{square of depth} = 16 \text{ tons}$ ,  $s=1$ . Therefore

$$k_1 = \frac{.006}{16.006} = .000375, \text{ and ult. span} = 2667.$$

This latter bar has therefore double the economic merit of the other.

As another example let us take the Conway tube. The calculation of the value of  $k$  for this is rendered a great deal more complicated by having to consider the amount  $E$ , of the material abstracted to resist the wind-induced stresses. We shall, in the first instance, assume that no wind will act upon it. Taking then  $w_1$  or the total dead weight  $= 1112$  tons (this is the same as in our calculation at page 194\*, but must be an under-estimate), and  $w_2 = 400$  tons, we found  $T$  to be equal to 7.18 tons, and  $c = 5.05$  tons; so that the factor of safety, as measured from the tension, is  $= 19 \div 7.18 = 2.65$  nearly.  $G$  may here be taken equal to 1050 tons, no value for  $E$ , but only keelsons, &c., which are not directly concerned in the girder action, having to be deducted. We have then  $F=62$ ,  $w=1512$ . And therefore

$$k_{2.65} = \frac{1050}{1512 \times 400} = .001736,$$

$$k_1 = .000655, \text{ and } k_{3.5} = .002293.$$

And the ultimate spans (the proportion of depth to span  $= 1:18.35$ , page 234, being maintained) would be as follows:—

With factor of safety $= 1$ ,	Ultimate span $= 1527$ feet.
“ “ 2.65,	“ 576
“ “ 3.5,	“ 436.2

We see then that even were no such antagonistic force as the wind to exist, it would be almost impossible to construct the Conway tube

with a sufficiently high factor of safety, the economic merit of the structure being so low; with a value of  $k_{2.5} = .0022925$ ,  $s=400$ ,  $w_2=400$ , and  $F=62$ , we find by formula (3) the weight of  $G$  alone to be  $= \frac{.00917}{.00083} \times 462 = 5152\frac{1}{2}$  tons.

We offer the following as an approximate calculation when the effect of the wind is to be allowed for. At page 196 it was shown that the wind, estimated at 30 lbs. per superficial foot, causes at the edges of the booms a stress of tension  $T$  equal to 1.875 tons, or  $eT=1.4$  tons. Now here occurs the principal difficulty in the calculation; we require to fix upon a certain factor in computing the amount of  $E$  to be abstracted to resist the wind-induced stresses, but this factor should evidently bear some relation to the factor applied to the stresses produced by the vertical pressure of the total weight supported. If we demand for  $E$  1 inch of sectional area for every 4 tons of stress, although this is reasonable in itself, it would be out of all proportion to the stress to which the remaining material would be subjected by the vertical pressures; this great discrepancy being caused by the excessive weakness of the structure. We shall, therefore, give the results for different ratios of section to stress.

1st, When  $E$  is calculated at the rate of 4 tons per inch (that is, for  $c$  and  $eT$ , but not to cover joint-plates), the wind stresses appropriate the  $\frac{1.4}{4}$  part of the whole section at the midspan, or 503 inches; and the weight of the iron thus taken from  $G$  will be  $= \frac{2}{3} 503 \times 400 \times .0015$  ton = 201 tons, to which we may add 49 tons for the proportion of joint-plates; this makes  $E=250$  tons;  $F$  will therefore be  $= 62 + 250 = 312$  tons, and  $G = 1050 - 250 = 800$  tons;  $w_2=400$ , and  $w_1=1112$ , as before. And to obtain the value of the factor of safety, since the metal left for girder action is only  $= \left(1 - \frac{1.4}{4}\right) = \frac{2.6}{4}$  of that which gave  $T=7.18$  tons, the value of  $T$  will now be  $= 7.18 \div \frac{2.6}{4} = 11.05$ .

The excess of  $T$  here given over the value 9.053, obtained at page 196, arises from the discrepancy above referred to. From these data we readily deduce the following factor of safety  $= \frac{19}{11.05} = 1.72$ .

$$k_{1.72} = \frac{800}{1512 \times 400} = .001323$$

$$k_1 = .000769$$

$$k_{3.5} = .002692$$

The ultimate span with this latter value (which corresponds with the proper factors of safety) would be only  $= 1 + .002692 = 371\frac{1}{2}$  feet. Showing that it would be altogether impossible to construct a bridge on the system of the Conway tube—having an effective depth like it of less than  $\frac{1}{18}$ th of the span, which with a movable loading at the rate of



1 ton per foot of span, and subjected to a windstorm equivalent to 30 lbs. on the superficial foot, would still have a factor of safety equal to 3.5—*unless the span were under 371½ feet.*

2d, When E is calculated at the rate of 6 tons per inch, the part of the midspan section appropriated amounts to 335 inches; so that, T being now equal to  $7.18 + \frac{6-1.4}{6} = 9.365$ , the factor of safety against gravitation will have a value equal to  $19 \div 9.365 = 2.03$  nearly; and E, taken with the same proportion for joint-plates as before, amounts to 167 tons; therefore  $G = 883$  tons, and

$$k_{2.03} = \frac{883}{1512 \times 400} = .00146.$$

This is a very near approximation to the true state of the Conway as calculated at page 196; we there have the factor of safety  $= 19 \div 9.053 = 2.1$  nearly. The corresponding value of  $k$  will be given with sufficient accuracy from the above—thus

$$k_{2.1} = \frac{2.1}{2.03} \times .00146 = .00151, \text{ say } = .0015.$$

From this we obtain approximately the ultimate span for the Conway tubes under their present condition of stress, &c.

$$= 1 \div .0015 = 667 \text{ feet.}$$

We might proceed to find still more exactly the value of  $k_{2.1}$  for the Conway, but it is not of sufficient consequence, since such would not be applicable to other spans, without a separate estimate of the value of F for each.

We shall now endeavor to arrive at correct values of  $k$  for open-work girders, such as described at pages 150, 164, &c., having a depth equal to  $\frac{1}{8}$ th of the span.

When the span is short, the factor E may be neglected; and therefore G becomes identical with the weight of the girder. Consequently

$$\text{we have } G = \text{tabular number} \times \left( \frac{S}{8} \right)^2$$

For these girders,  $w_1 = \frac{1}{2}S$  tons,  $w_2 = S$  tons,  $w = 1\frac{1}{2}S$  tons, and the factor of safety calculated from the most severely stressed parts is as nearly as may be  $= 4$ . Therefore

$$k_4 = \frac{G}{wS} = \text{Tab. number} \times \left( \frac{S}{8} \right)^2 \div 1\frac{1}{2}S^2 = \frac{1}{96} \text{ of Tab. number.}$$

$$k_1 = \frac{1}{384} \text{ Tab. number, and } k_{3.5} = \frac{1}{109.7} \text{ Tab. number.}$$

For the 1st and 9th forms (page 164) with the load at the lower level, the tabular numbers are respectively .1078 and 1.010. Consequently the values of  $k$  are as follow:—

First form . . . . .	$k_1 = .000281$	$k_{3.5} = .000983$
Ninth form . . . . .	$k_1 = .000263$	$k_{1.5} = .000921$

It has here been assumed that allowances of metal in proportion to stress are the same for any span. The correctness of this will be apparent, when we consider that  $w$ , the total load supported, increases much more rapidly than the span; and if exactly the same pattern

of girder were retained, would warrant an increase in the value of  $c$  for the bracing struts. As, however, it is necessary to provide a greater number of points of support to the roadway in long spans, it becomes necessary either to supply suspension rods, or to cut up the simple bracing into one or more series, the result being that, as stated in Prop. III., page 233, so long as the general character of the structure is retained, the weight  $G$  varies as  $s \times w$ . Of course we do not mean that this holds good with perfect exactness, but it is sufficiently accurate for the purposes of a general view of the subject. The value of  $k$  may then be obtained from any size of bridge, since it only expresses inversely the economic merit of any particular form of construction. As some readers, from not having sufficiently studied the previous articles, may not see very clearly how the above values of  $k$  have been obtained, we here offer a general approximate estimate of the weight of a double girder.

*Estimate of the Weight of an Openwork Girder, having a Depth equal to  $\frac{1}{10}$ th of the Span.*—When the loading is assumed to be concentrated at the level of the upper or lower boom, the stresses produced in the corresponding bays of the two booms do not agree; thus, in Table X., page 149, the stresses in the central bays of the upper boom amount to only 2.25 units, while in the corresponding bays of the lower boom they amount to 24. Now in all such cases it is the greater stress which is given by the common formula, viz.: stress in booms  $= ws \div 8D$ ; and the more numerous the series of bracings and the greater the number of triangles in each series, the more nearly will the stresses in the two booms correspond with one another; and it may be remarked that the stresses at the actual centre of the span are both really the same as given by the formula. This is a point of some importance when, as in Table XI., the lower boom has its central bay less strained than its central joint; in such a case the joint-plates must be of extra thickness compared with the plates. Let us assume, then, that the formula gives the central stresses with sufficient accuracy, the error will be on the safe side, and will most affect the shorter spans. The central sectional areas will be equal to  $ws \div 8D \cdot c$  for the upper, and  $ws \div E \cdot eT$  for the lower boom. Now, if we could vary the sections in proportion to the stresses, the average sectional areas would be two-thirds of these central ones. We can, with some approach to accuracy, apportion the sections to the stresses to a considerable distance on either side of the midspan, but there are various practical objections to reducing the sections towards the extremities below a certain percentage of the central ones—we may take these limits at about 65 per cent. for the upper, and 35 per cent. for the lower boom. The resulting average sections are about 75 per cent. for the former, and 70 per cent. for the latter, and the amounts to be added for joints and rivets about 15 and 20 per cent. respectively; the top being understood to be built up of plates and angle-irons, and the bottom of bars without longitudinal lines of riveting. The weights of the booms will therefore be as follow,  $c$  and  $eT$  being taken equal to  $3\frac{1}{4}$  and 4 tons respectively:—

Weight of upper boom,

$$= \frac{ws}{8D\frac{3}{4}} \times .75s \times 1.15 \times .0015 \text{ ton} = \frac{ws^2}{D} \cdot 00004975 \quad . \quad . \quad (10)$$

Weight of lower boom,

$$= \frac{ws}{8D\frac{1}{4}} \times .70s \times 1.20 \times .0015 \text{ ton} = \frac{ws^2}{D} \cdot 0000394 \quad . \quad . \quad (11)$$

When  $D = \frac{1}{8}s$ , these become respectively

$$ws \times .000398 \text{ and } ws \times .000315.$$

*The Bracing.*—When all the loading  $w$  is assumed to be transmitted through the bracing (this rather exaggerates the effect of the loading), then the braces at one end of the structure are altogether conveying a stress  $= \frac{1}{2}w \sec \theta$ , and the length of each series of braces is  $= s \sec \phi$ . We may assume one-half of the braces to be struts, and the other ties; and if all the struts were retained with the same sectional area throughout the span, their total weight would be  $= \frac{1}{4}ws \sec \theta \sec \phi \times .0015 \div c$ , and similarly the weight of the ties would be equal to the same with  $eT$  substituted for  $c$ ; and when  $\theta = 45^\circ$  these weights would become—

$$\text{Struts} = \frac{ws}{c} \times .00075 \quad \text{Ties} = \frac{ws}{eT} \times .00075.$$

Now if all the loading were fixed or constant, and the sections everywhere made in proportion to the stresses, the average sections would be equal to half of the sections at the extremities of the girder, and consequently the weights equal to only half of the above. Practically, we may take the average section of the struts at 70, and that of the ties at 60 per cent. of the strongest, and allow for rivets and extra lengths 10 per cent. for the former, and 5 for the latter; so that, taking  $c = 2\frac{1}{2}$  and  $eT = 3\frac{1}{2}$ , we have

Weight of bracing struts,

$$= 7 \cdot \frac{ws}{2 \cdot 5} \times .00075 \times 1.10 = ws \times .000231 \text{ ton} \quad . \quad . \quad (12)$$

Weight of bracing ties,

$$= 6 \cdot \frac{ws}{3 \cdot 5} \times .00075 \times 1.05 = ws \times .000135 \text{ ton} \quad . \quad . \quad (13)$$

$$\text{Total bracing} \quad . \quad . \quad = ws \times .000366 \text{ ton.}$$

And for the total weight of the girder we therefore have

Upper boom	.	.	.	.	$= ws \times .000398$
Lower boom	.	.	.	.	$= ws \times .000315$
Bracing	.	.	.	.	$= ws \times .000366$

$$\left. \begin{array}{l} \text{Total of girder taken} = s \text{ long, and without} \\ \text{end pillars,} \end{array} \right\} = ws \times .001079 = G$$

Now since  $k = \frac{G}{ws}$ , we simply have  $k_1 = .00108$ ,  $k_1 = .00027$ , and  $k_{3.5} = .000945$ . Which results are sufficiently confirmatory of those obtained from the tabular numbers.

Let us now inquire what reduction can be made upon the values of  $k$ , by employing superior materials, greater depth, &c. From the foregoing investigation we find the relative weights of struts to ties as follows:—

Struts of bracing	= .000231	Ties of bracing	= .000135
Top of girder	= .000598	Bottom of girder	= .000315
	<hr/>		<hr/>
	.000629		.000450

Now, if we adopt steel for the ties, we may reduce the sections to one-half; and by selecting a suitable variety of hard wrought iron for the struts, we may reduce their sections by, say 15 per cent. The changes are as follow:—

Proportional Weight of Girder when ordinary wrought iron is used.		Proportional Weight of Girder when steel is used for the ties, and selected wrought iron for the struts.	
Struts	. . . . 629	Struts	. . . . 535
Ties	. . . . 450	Ties	. . . . 225
	<hr/>		<hr/>
	1079		760

A corresponding reduction will take place in the values of  $k$ . Assuming the somewhat exaggerated value of .001 for  $k_{3.5}$  in ordinary wrought iron girders, with a depth equal to  $\frac{1}{3}$ th of the span, we have the following changes:

Ordinary wrought iron.	Steel and selected iron.
$k_{3.5}$ = .001000	$k_{3.5}$ = .000705
$k_{1.0}$ = .000286	$k_{1.0}$ = .000202
$k_{3.0}$ = .000857	$k_{3.0}$ = .000604
$k_{2.1}$ = .000600	$k_{2.1}$ = .000423

By increasing the depth of the structure, we may obtain still lower values of  $k$ : there are, however, objections to carrying this source of economy too far.

We have seen that the weight of the booms, compared with that of the bracing, is nearly as 2 to 1; if we increase the depth from  $\frac{1}{3}$ th to  $\frac{1}{6}$ th of the span, we reduce the stresses in the booms in the proportion of 2 to  $1\frac{1}{2}$ , while the weight of the bracing, if we can retain the same values of  $c$ , is not affected; the whole weight of the girder is therefore reduced in the proportion of 3 to  $2\frac{1}{2}$ , assuming the values of  $c$  and  $eT$  to remain unaltered; this would give us, when steel and selected wrought iron are employed, the values of  $k$  as follows:  $k_1$  = .00017,  $k_{2.1}$  = .00035,  $k_3$  = .00050, and  $k_{3.5}$  = .00059.

For short spans it might be far from economical to make use of expensive steel and selected iron, but when we have to deal with very long spans, the ultimate saving of expense from their adoption will be very great indeed: this will be evident from an inspection of the values of  $G$  in Table IV.

When, on the other hand, we diminish the depth of the girder, we increase in very nearly the same proportion the weight of the booms, without affecting very materially that of the bracing. Taking, for girders having a depth equal to  $\frac{1}{3}$ th of the span,  $k_{3.5}$  = .001000 as a standard, and estimating in this manner the weights for other proportions, we get the following values of  $k$  for openwork girders of good ordinary wrought iron work.

TABLE III.

Ratio of span to depth.	$k_1$	$k_{2.1}$	$k_{3.0}$	$k_{3.5}$
6	·000238	·000500	·000714	·000833
8	·000286	·000600	·000857	·001000
10	·000334	·000700	·001000	·001167
12	·000381	·000800	·001143	·001333
14	·000429	·000900	·001286	·001500
16	·000476	·001000	·001428	·001667
18	·000524	·001100	·001571	·001834
20	·000571	·001200	·001714	·002000

From defects of this method of deriving the weights, the values in the table for the shallower girders must be considered somewhat exaggerated.

We may now offer an example of the complete calculation of the weight of  $G$ , of the whole of one double girder, and of the half of the complete viaduct of two lines of railway. Let  $s$  be taken equal to 400 feet as in the Conway tube, then  $w_s=400$  tons, and by Table II.,  $E=22$  tons, and  $F=190$  tons; therefore, when  $k_{3.5}$  is taken  $=\cdot001$ , we have

$$G = \frac{s/k}{1-s/k} (w_s + F) = \frac{\cdot4}{\cdot6} 590 = 393 \text{ tons.}$$

Complete girder or  $G+E=415$  tons.

Share of complete structure due to one line of }  
 railway, including timber, &c. . . . }  $=G+F=583$  tons.

This is a very satisfactory result to contrast with the 1112 tons of the Conway, when we bear in mind that the factors of safety are respectively 3·5 and 2·1.

A fairer comparison will be given by adopting a factor of safety equal to that of the Conway, viz: 2·1; although this will still be unjust towards the deep openwork structure, in so far as the value of  $F$  is unduly high when such a factor is employed.

With a factor  $=2\cdot1$ , and ordinary good iron, we have seen that  $k_{2.1}=\cdot0006$ ; so that  $G=\frac{\cdot24}{\cdot76} 590=186$  tons only, showing the great influence which the value of  $k$  has upon the weight of very long girders.  $G+E=208$  tons, and  $G+F=376$  tons instead of 1112 tons. By the employment of steel and selected iron, and a depth equal to  $\frac{1}{8}$ th of the span, we have shown that  $k_{2.1}$  might be reduced to about ·00035. This gives us

$$G = \frac{\cdot14}{\cdot86} 590 = 95 \text{ tons, } G+E=117, \text{ and } G+F=285 \text{ tons.}$$

The adoption of such a structure as this, though showing the same general factor of safety as the Conway tube, would not of course be advisable. Let us see what is the lightest that might be recommended. Many engineers believe that a factor  $=3$  gives ample surplus strength in large structures. Now the value of  $k_3$ , when steel and selected iron are used, along with a depth equal to  $\frac{1}{8}$ th of the span, is  $=\cdot000604$ . Consequently, for a span of 400 feet, we have

$$G = \frac{400 \times 0.000604}{1 - 400 \times 0.000604} (W_2 + F) = \frac{0.2416}{0.7584} 590 = 188 \text{ tons.}$$

Complete double girder . . . =  $G + E = 210$  tons.

Half of complete structure fitted  
for two lines of railway includ-  
ing timber, permanent way, &c. } =  $G + F = 378$  tons.

With ordinary iron  $k_3 = 0.00857$ , and hence  $G = 308$ , or 120 tons more than when superior materials are employed.

It then appears that, by employing an openwork structure having a depth equal to  $\frac{1}{8}$ th of the span, the Conway tube, with a factor of safety equal to only 2.1, and weighing more than 1112 tons, could have been replaced by any of the following:—

1. A structure composed wholly of wrought iron except the planking and other timbers of the roadway, which including timber, permanent way, &c., would, with a factor of safety also equal to 2.1, have weighed only 376 tons.

2. A structure as above, but with a factor of safety equal to 3, which would have weighed only 498 tons.

3. A structure as above, but with a factor of safety equal to 3.5, which would have weighed only 583 tons.

4. A structure composed of steel and selected iron for the girders, and ordinary iron and timber for the other parts, which with a factor = 2.1 would have weighed only 310 tons.

5. A structure as above, but with a factor equal to 3, which would have weighed only 378 tons; or

6. A structure as above, but with a general factor of safety equal to 3.5, which would have weighed only 422 tons.

These facts have, to some considerable extent, been long known to a few; yet the public has been led to regard such structures as the Conway, Britannia and Victoria Bridges with pride. Another generation may, with more reason, classify them—at least in so far as the *superstructures* are concerned—as perhaps the most expensive engineering blunders of the century.

TABLE IV.—Containing the Values of  $G$  in Tons, corresponding with given Values of  $k$  and  $s$ , and with the Values of  $F$  given in Table II.

Span in feet=	100	200	300	400	500	600	700	800	Ultimate spans in feet.
Value in tons of $W_2 + F$ being whole load supported less $G =$	138	231	431	590	763	953	1165	1403	
Values of $k$	Values of $G$ .								
0.0005	7.3	31.2	79.6	147.5	254	408	627	935	2000
0.0006	8.8	38.3	94.6	186	327	536	843	1295	1667
0.0007	10.4	41.0	115	230	411	690	1119	1786	1429
0.0008	12.0	53.5	136	278	509	880	1483	2294	1250
0.0009	13.6	61.7	159	332	624	1119	1930	3608	1111
0.0010	15.3	70.3	185	393	763	1430	2718	5612	1000
0.0012	18.8	88.7	242	545	1144	2451	....	....	833
0.0015	24.4	120.	353	885	2289	8577	....	....	667
0.0020	34.5	187.	647	2360	$\infty$	....	....	....	500

In the case of the Victoria Bridge, however, all must admire the boldness, skill, and success attendant upon the founding and rearing of its piers of masonry in the rushing stream of the St. Lawrence. Having obtained the values of  $G$ , as in Table IV., we can readily ascertain the weight of the complete girder, or that of half of the complete structure for two lines of railway, by simply adding the values of  $E$  or  $F$  contained in Table II. We give the following examples, in which  $k=.001$ .

TABLE V.

Span in feet . . . =	100	200	300	400	500	600	700	800
$G$ in tons . . . . .	15.3	70.3	185	393	763	1430	2719	5612
Girder complete, or $G+E$	15.5	72.5	190	415	810	1516	2863	5839
Bridge complete per line, including timber, &c., = $G+F$ . . . . .	53.8	151.5	316	583	1026	1783	3183	6215
Total load supported by the girder = $w = w_2$ + $F+G$ . . . . .	154	252	616	983	1526	2333	3883	7015

Edinburgh.

R. H. B.

(To be Continued.)

*Lambeth New Suspension Bridge.*

From the London Artizan, December, 1862.

Lambeth new Suspension Bridge, has a total length over all of 1040 feet, and a length between the abutments on the shore at either side of 828 feet. Its extreme width is 32 feet, which is divided into 20 feet for roadway, and six feet for each of the footpaths, and its total height above high-water mark is 21 feet clear. The rise or curve of the structure is one in 22 feet on the bridge itself, and one in 20 feet on the approaches. For such a steep rise the bridge itself should have given a greater headway than 21 feet, but this would have involved heavy outlay in raising the approaches at either end, and, of course, could not be attempted in a structure the total cost of all connected with which, even to painting and roads to it, was not to exceed £40,000. The suspension ropes are taken over four pairs of towers, two of which at either end rest on the abutments of solid masonry, and two are upon circular piers in the bed of the river. Over these towers the suspension ropes are carried, sustaining the bridge beneath in three spans of 280 feet in length each. These towers, though they look exceedingly light, are reported to be as many as seven times stronger than any strain they can ever be called upon to bear, even supposing the road and footway of the structure to be densely packed with a crowd of people. Each tower is of boiler plate  $\frac{1}{4}$ -inch thick, strengthened with  $2\frac{1}{2}$  ins. angle iron, and built upon the cellular principle adopted in the Britannia Bridge, and in the double sides of the Great Eastern. The sectional area of these towers gives 120 square inches of iron, and the utmost weight which can come upon them, when

the bridge is fully weighted to its load strain is only  $2\frac{1}{2}$  tons per inch, —just half the strain which the Britannia Bridge, on the same principle, has always to carry, and, we believe, about one-third of the strain upon the great Victoria Bridge at Montreal. At the abutments, as we have said, two of these towers rest on masonry of the most solid description. On the river piers they are fixed on circular cast iron cylinders, which are taken down 18 feet below the bed of the river and into the London clay. These cylinders are 12 feet diameter and  $1\frac{1}{2}$  inches thick, and the mode of fixing them was, though on a very small and easy scale, much the same as that pursued with the very difficult foundations of the piers of Mr. Brunel's great bridge at Saltash. The cylinders were lowered into the places they were to occupy and forced down below the bed of the river. The water and mud were then dredged out, and the cylinder filled to a depth of nine feet with solid concrete, then 3 feet of solid brickwork, finishing with a brick invert arch, and thence a lining of 3 feet of solid brickwork up to the top of the cylinder on which the tower rests. This lining of brickwork, therefore, leaves a circular opening 6 feet wide in the cylinder down to the bed of the river, so that the work can be examined, if necessary, to its very foundations from time to time.

The ropes by which the bridge proper is suspended are of the best charcoal iron wire, and were made by Newall and Co., on the works of the bridge itself. There are two of these main ropes on each side, each being made up of 7 massive ropes banded together, and each of these 7 ropes containing 7 strands of wire, two-tenths of an inch in diameter. The sectional area of each main rope is 100 square inches, and their united strength is guaranteed to bear a strain of 4000 tons, and in detail has been proved to that amount, though the greatest strain that can come upon the bridge is only estimated at 600 tons with ordinary traffic. These ropes are secured at either end round what may be termed a massive eyebolt, with 28 screw-bolt fastenings, each fastening having already been tested with a strain of 82 tons. The "anchorage" in which all are finally secured on both sides of the river is on the Lambeth shore, where the ground is good, formed by massive iron holdfasts or beams, built into a solid masonry of concrete 20 feet below the surface. On the Westminster side, where the ground is little better than loose peat, the anchorage is made by a series of 12 square cast iron caissons, each weighing 7 tons, sunk into the gravel, and filled with concrete, and the square space thus enclosed by the whole 12 dug out and filled with concrete, so as to form one immense compact bed of iron and concrete 20 feet below the surface. Thus far, therefore, the ends of the ropes are as firmly secured as if they were taken down to the centre of gravity itself. It remains to be seen how, in this situation, the wire will resist the attacks of its great destroyer, rust. The want of efficient precautions against this apparently insignificant item of wear and tear has brought many wire-rope bridges to a premature end. From the wire ropes so secured come down a regular series of lattice tie-rod uprights, with diagonal bracings on each side, at an angle from the roadway of 45 degrees. Be-



yond that these latter are placed closer than usual, and of greater strength, there is not much that differs in principle from other suspension bridges. The roadway in suspension bridges is usually hung to the ropes and tie-rods, and there is an end of the work. In Mr. Barlow's bridge, however, a new principle is introduced, which almost, if not quite, does away with the lateral and vertical motion so dangerous to ordinary suspension bridges, and which has rendered some in this country and many in America almost useless for heavy traffic. This consists of taking under the floor of the bridge what may be called two powerful longitudinal box girders, one on each side. The sectional area of each of these is 40 inches, and each is 2 feet 3 inches deep by 18 inches wide. These diminish any upward or downward movement to a *minimum*, and absolutely check all lateral swing. To these girders, which are, in fact, the backbone of the whole structure, the lattice tie-rods we have described are fastened, and thus such rigidity is given that, calculating according to the strain wrought iron ought to bear per inch, it is said that the whole floor of the bridge, if laid sideways, would even then be strong enough for its traffic.

Between these main box girders, which run from end to end of the whole structure, wrought iron cross girders are laid at intervals of four feet apart. On these again are wrought iron plates for the roadway, which is paved with a wooden pavement, set in mineral pitch, so as to give elasticity to the thoroughfare, while securing the iron-work beneath it from the action of either air or water. The footways on each side have a width of 6 feet, though they certainly do not seem to have even this narrow limit. After the spacious sidewalks of new Westminster, these appear like mere alleys by comparison. These footpaths on each side are carried on cantilevers or iron brackets projecting from beneath the roadway. Everything being made to do some duty in the strength of this singular bridge, the parapets of the footways are formed of wrought iron lattice work, which in itself gives a support and rigidity to the otherwise light path. The paving of the footways is of Portland stone from old Westminster Bridge, cut in thin neat slabs. In the ornamental scrollwork of the brackets which carry them, the mains of the Lambeth Gas Company, 18 inches in diameter, cross the river, one under each side of the bridge. From the river these have a rather ornamental moulding appearance,—a matter in which the whole structure is, to say the least, deficient.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

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For the Journal of the Franklin Institute.

*Comments on Professor Tyndal's Lecture on Force.* By ELI W. BLAKE.

The lecture of Professor Tyndal, published in late numbers of this Journal, is entitled a "Lecture on Force." It might, however, be more appropriately entitled a Lecture on the Dynamic Theory of Heat. I had proposed to myself to examine some of the bold and extravagant

statements put forth in this lecture in exemplification and support of this theory; but as a popular lecture on an abstruse topic is not, perhaps, a fair subject of scientific criticism, I pass these by and make the lecture rather the occasion than the subject of this communication.

Whatever foundation there may be in nature for the dynamic theory of heat, it is certain that arguments have been employed in its behalf which are based on error. To correct one of these is the object of this paper.

Professor Tyndal states that a German named Mayer, to whom he gives the credit of having originated the dynamic theory of heat, computed the mechanical equivalent of heat from the velocity of sound. Other advocates of this theory have alleged that the mechanical equivalent thus found is in exact accordance with that deduced from other sources. No argument in behalf of the theory has been used by its advocates with more confidence and effect than this alleged coincidence; and it is not to be denied that such a coincidence, if the computations were founded upon correct and sufficient data, would be significant, and indicative of a general law governing the relations of heat to force. It is proposed to show that those who have computed the equivalent from the velocity of sound, have not been in possession of correct and sufficient data for that purpose; and consequently that the alleged coincidence, however obtained, has no such significance as has been ascribed to it.

In order to compute the mechanical equivalent of heat, from the velocity of sound, it is necessary to know, first, the true theoretical velocity of the sonorous wave independently of any acceleration by heat; and secondly, we must find by experiment the actual velocity of the same wave. Then, assuming the difference of these velocities to be due to heat, and knowing the ratio in which the elastic force of the air is increased by the heat evolved by its compression, we may compute the mechanical equivalent of the heat.

Let us look at the character of the data upon which these computations have been founded. Newton, who was the first to attempt to solve the problem of the velocity of sound, arrived at the conclusion that waves of sound move with the velocity which a body would acquire by falling through half the height of a homogeneous atmosphere. But upon examining his reasoning on this subject, as given in the *Principia*, we shall be struck with the fact that it lacks the precision and clearness of logical sequence which usually characterize Newton's mathematical arguments. Other mathematicians, not satisfied with Newton's reasoning, yet not perceiving the true nature of its defect, have attempted to solve the problem by processes differing from that employed by Newton, yet involving the same defect. As they all arrived at the same conclusion as Newton did, it has been accepted as an established truth that the theoretical velocity of waves of sound is that which a body would acquire by falling through half the height of a homogeneous atmosphere (or about 946 feet per second), and that all sonorous waves have the same theoretical velocity. This, no

doubt, was assumed to be the theoretical velocity of sound by those who have computed from it the mechanical equivalent of heat.

In the next place we would inquire, what have they assumed to be the actual velocity of sound as found by experiment? Numerous experiments have been made by different observers, but their results differ widely, varying from 1100 feet or less, up to 1474 feet per second. Now it cannot be shown that one of these observations is less correct than another. By what rule, then, has one of them been accepted and the rest rejected? If a mechanical equivalent of a prescribed value was sought for, no doubt, within this wide range of experimental velocities, one could be selected that would meet the exigency; but what would be the value or significance of a coincidence obtained in that way?

But this is not the only nor the principal objection to the legitimacy of such a mechanical equivalent. It is not true, as here assumed, that waves of sound have all the same velocity. On the contrary, their theoretical velocities vary through a still wider range than those found by experiment.

Waves of sound are of two kinds, viz: waves of rarefaction and waves of condensation. Waves of rarefaction vary in their theoretical velocities from that which would be acquired by falling through one-fourth the height of a homogeneous atmosphere (about 668 feet per second), up to that which would be acquired by falling through one-half the height of a homogeneous atmosphere (about 946 feet per second.) Waves of condensation vary in their theoretical velocities from that which would be acquired by falling through half the height of a homogeneous atmosphere, or 946 feet per second, upward without limit. The cause of the variation in the velocities of waves of sound is their difference in intensity; that is, in the extent to which the air is condensed or rarefied in the wave. The law of variation is this, viz: the velocity of the wave is as the square root of the ratio of the density of the wave to the natural density of the air through which it moves. The velocity, 668 feet per second, is that which pertains to a wave whose density is half the natural density. This is the smallest velocity any sonorous wave can have, for the reason that if the cause which at any point originates a wave, produces at that point any greater degree of rarefaction than corresponds to a density of one-half, still the wave which will be propagated from that point will be one whose density is half the natural density. The velocity supposed by Newton and others to pertain to all sonorous waves, viz: that which a body would acquire by falling through half the height of a homogeneous atmosphere, is that which belongs to a wave whose density is equal to the natural density. This lies at the boundary between waves of rarefaction and waves of condensation. Strictly, it is the only velocity in the whole range which no wave can have, as in this case the intensity of the wave is 0.

The laws of waves, as here stated, are susceptible of rigid demonstration. The course of reasoning by which they are established may be seen by reference to an article in the *American Journal of Science*,

2d Series, Vol. 5, page 372. The waves contemplated in the article referred to, are waves of condensation only; but the same course of reasoning, *mutatis mutandis*, applied to waves of rarefaction, will give the results above stated as pertaining to that class of waves, with the exception of the lower limit to their range of velocities. That there is such a limit follows from the principles developed in another article in the same Journal, 2d Series, Vol. 9, page 334.

From what has been stated it follows that in order to know the true theoretical velocity of any wave of sound, we must know its density. And as the densities of the waves whose actual velocities have been observed, have not been noted by any observer, it is obvious that we do not possess the requisite data for determining the mechanical equivalent of heat from the velocity of sound.

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*Proceedings of the Manchester Association for the Prevention of Steam Boiler Explosions.*

From the *Mechanic's Magazine*, November, 1862.

At the last ordinary monthly meeting of the executive committee of this association, held on Tuesday, Nov. 25, 1862, Mr. L. E. Fletcher, chief engineer, presented his monthly report, of which the following is an abstract:—

During the past month there have been examined 365 engines and 547 boilers. Of the latter 8 have been examined internally, 60 thoroughly, and 479 externally, in which the following defects have been found:—Fracture, 5 (1 dangerous); corrosion, 38 (3 dangerous); safety-valves out of order, 13; water-gauges ditto, 31; pressure-gauges ditto, 9; feed apparatus ditto, 6; blow-off cocks ditto, 47 (1 dangerous); fusible plugs ditto, 3; furnaces out of shape, 6 (2 dangerous); blistered plates, 3; deficiency of water, 1. Total 162 (7 dangerous). Boilers without glass water-gauges, 10; without pressure-gauges, 2; without blow-off cocks, 38; without back pressure-valves, 78.

An explosion has occurred this month to the boiler of a first-class passenger locomotive engine, by which 3 persons were killed and others injured. It was considered to be perfectly safe, had been on duty the previous day, and was being cleaned ready for work at the moment the explosion occurred.

It will be remembered that reference was made in the July, 1861, report, to another explosion of a locomotive boiler, which took place while the train was running; and since that time three others have occurred in addition to the one first alluded to, thus making five during that period with this class of boiler.

The cause of explosion in four of these cases proved to be thinning of the plates from internal corrosion. I have only had an opportunity of examining the plates of one of these exploded boilers, but from official reports, it appears that the corrosive action had developed itself in a very similar manner in each instance, which in the one personally examined was as follows:—The corrosion had eaten grooves or furrows parallel with and close to the edge of the overlaps of the

plates, at some of the longitudinal seams of rivets; the furrows being on the outer plates of the overlap, while the deepest one, and that from which the explosion had sprung, was situated nearly midway between the smoke-box and fire-box.

This furrowing action will be at once recognised by those who have been in the habit of observing the influence of wear upon the ordinary internally fired double-flued boiler, in general use in Lancashire. In this boiler the furrow is found on the inner surface, both of the front and back end-plates, but more especially at the front, and lies close to the edge of the internal flue angle-iron, which it partially encircles; the furrow being deepest at the crown, and gradually dying out in about six or nine inches on each side. It is sometimes found in the root of the angle-iron itself; the choice of position between the plate and angle-iron, apparently depending upon their comparative power of resistance. When the plate of the furnace-tube is flanchd, the furrow more frequently occurs at the springing of the flanch than at the end-plate. Furrowing also is very commonly found at the transverse seams of rivets at the underside of boilers; the furrows in these cases being immediately at the edges of the overlaps, and most frequently on the external surface of the plates, but sometimes on the internal. This action is more severe in long boilers than in short ones, and at the middle of their length rather than at their ends. It is seldom, if ever, developed at the longitudinal seams of these boilers, except where leakage takes place, and is then found to be most severe when the objectionable plan of construction is adopted, of placing the seams of rivets in one continuous line from one end of the boiler to the other. Such are some of the manifestations of furrowing constantly met with in the boilers under the inspection of this association, and it may be interesting to attempt to trace the cause.

Furrowing appears to be the result of corrosive and mechanical action combined. The mechanical action, such as an alternate buckling of the plates, strains and frets them, and thus renders them more susceptible to the influence of corrosion than the parts at rest. Where these furrows are internal, the corrosive element is furnished by the water, which is rarely, if ever, free from acidity; and when the furrows are found externally in the flues, as explained above, the corrosion may perhaps be attributed to the influence of gases.

The cause of the buckling action varies according to the position in which it occurs.

In the stationary boilers above referred to, when found in the front end plate, it may be ascribed to the alternate elongation of the internal flues, more especially at the furnace end; and, when at the bottom of the external shell, to the unequal expansion of the plates consequent upon the different strata of temperature in the water. The temperature of these strata varies with the distance from the bottom of the boiler, in proof of which it may be stated that it is frequently found that while the water is boiling on the surface, that at the bottom of the boiler will not scald the hand. Those boilers are most conducive to this inequality of temperature which have a defective circu-

lation of water, are so set that the least heat from the fires passes beneath them, and fed with comparative cold water introduced at the bottom. It will be readily seen how these varying temperatures induce unequal expansion of the plates, and thus put upon the seams of rivets most irregular and severe strains. In this way, it is thought that the buckling action is produced, which results in furrowing at the bottom of stationary boilers.

In locomotive boilers the buckling at the longitudinal seams, in the cylindrical portion of the shell, arises from its not being of true circular form in the vicinity of the overlaps. The tendency of the internal steam pressure is to correct this, and to induce a true circular form, and thus a cross strain, which may be correctly termed a "girder strain," is put upon the plates at a short distance on each side of the line of rivets; from this a change of shape ensues, which constantly varies with the pressure of steam. The position of the furrows is found to be that of greatest elasticity, being midway between the fixed ends of the fire-box and smoke-box, just where this buckling action would have most play. It will at once be seen that the thicker the plates the greater the leverage of the girder action, and thus to thicken their edges is only to aggravate the evil. The true circular shape may be maintained, as far as appearance is concerned, by substituting a butt-strip for the overlap, but this, from its one-sidedness, will not prevent the girder action, and, indeed, tends to make two furrows instead of one. Were an inner as well as an outer butt-strip introduced, the parts would be in equilibrio, and the strain then passing through the centre of the plates, they would be subjected to their legitimate tensile strain only, and the buckling action in question set at rest.

But whatever expedients may be adopted to meet special cases, as one after another may force itself upon attention, some general precautionary measure appears to be needed to guard against the subtle influence of corrosion. It is often found, in a line of one hundred rivets, to attack ten and neglect the remainder; in an entire boiler, it will affect one or two plates and not the rest; and even in a series of boilers will select one in preference to the others. No doubt careful analysis might detect some predisposition in the metal, and thus account for the apparent anomalies, but the difficulty of foretelling the precise course of corrosion must be candidly acknowledged, and hence the necessity, as just stated, for the adoption of some sweeping precautionary measure, which will embrace every case without distinction.

The association meets the difficulty with its own members by affording them the opportunity of having what is technically termed a "thorough examination" of each of their boilers once a year, when all the seams as well as the surfaces of the plates, both outer and inner, are examined throughout, provided that the boiler is suitably prepared for the inspection. The conviction of the importance of these examinations—which such explosions as the one under consideration serve to deepen—may explain the frequency with which reference is made to this subject. Indeed, the association cannot hold itself responsi-

ble for the safety of any of the boilers under its charge, where the opportunity of making an annual "thorough examination" is withheld. In addition, it recommends to those members using multitubular boilers, that such an arrangement of tubes should be more generally adopted as will admit of a man's gaining access between them and the shell for the purpose of examination, while those should apply the hydraulic test annually, who are employing boilers which will not admit of complete examination.

From the experience derived from the boilers under the inspection of this association, it certainly appears hazardous to allow locomotives to work, as is very usually done, for five or seven years, without a complete internal examination; and it therefore becomes most important, either that some searching test should be adopted that shall at all times ascertain the sufficiency of the boilers without removing the tubes, or else that their construction shall be so modified that the parts may be rendered accessible to complete examination. The occurrence of four explosions to locomotive boilers, from internal corrosion, within the last eighteen months, must show the necessity of taking this subject into serious consideration.

*Setting Boilers.*—Considerable difficulty is experienced in examining many boilers from the contracted area of the flues; some, indeed, are altogether inaccessible. Boiler-setting appears to be left too much to the individual tastes of the bricklayer, and, consequently, flues of every variety of proportions are met with. A sketch has been drawn up of the proportions most generally approved, and at an early opportunity a description will be given—which space does not now permit—for the assistance of those who are re-setting their old boilers or laying down new ones; meanwhile, a drawing lies at the office of the association for the inspection of members.

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### *Consolidated Emery Wheels.*

From the London Chemical News, No. 152.

Some public trials took place last week in the Machinery Department of the International Exhibition, of Warne and Co's Consolidated Emery Wheel (Coles, Jaques, and Fanshawe's patent). The patentees have availed themselves of Walton's oxidized oil—exhibited in Class IV., 1156—as a means of consolidating emery; the mixture being formed into wheels, and then subjected to a process analogous to that by which ebonite or vulcanite is produced from india rubber. In this way a material of intense hardness and great durability is produced. The experiments we witnessed showed that a wheel of this material would grind with ease the hardest chilled iron, while steel and cast iron were cut with remarkable facility. The invention will prove of the greatest utility to engineers by saving time and labor in filing and polishing large castings—this kind of work being done with great ease and quickness. One experiment showed that the wheel could be made available for cutting teeth in circular saws, and many other applications of the material were suggested by prac-

tical engineers. We were informed that the wheels are already in use at the North London Railway Works, Bow, and some other large engineering establishments.

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*Description of a Feed-pipe Connexion for Locomotive Engines.* By  
Mr. ALEXANDER ALLAN, of Perth.

From Newton's London Journal, November, 1862.

Various constructions of feed-pipe connexion between locomotive engines and tenders have been used at different times; but the double ball and socket plunger pipes, made of brass, are most generally applied, in order to have a continuous metallic connexion allowing of blowing steam through into the tender without injury. These, however, are very expensive, requiring great nicety of fitting and much care in their management in work; and in consequence of sand and dirt getting in at the movable parts, they involve a serious outlay for maintenance; and in practice it is almost impossible to keep them perfectly tight, while if the joints be too tightly screwed up there is risk of the feed-pipes breaking.

To obviate these defects, and obtain a continuous metallic connexion, comparatively inexpensive, both in first cost and maintenance, and combining simplicity, durability, and efficiency, the writer has substituted a connexion, consisting of a simple brass or copper tube, coiled to a circle of considerable diameter, so as to have sufficient elasticity to allow for the vertical disturbance due to the unequal deflection of the engine and tender springs, and also for the extreme lateral range required in going round the sharpest curves, with a minimum strain on the joints. A solid-drawn brass tube is employed, varying from No. 17 to No. 14 wire gauge in thickness, or .060 inch to .085 inch, coiled to a circle of 3 feet to  $3\frac{1}{2}$  feet diameter.

In order to offer less resistance to bending, the tubes are made elliptical in section, about  $2\frac{1}{2}$  inches deep by  $1\frac{1}{2}$  inch broad. Tubes of circular section, 2 inches in diameter, have also been used, but they are more rigid than the elliptical tubes. Experiments have been made to ascertain the amount of force necessary to stretch and compress the coiled tube, and also to deflect it vertically and laterally through the extreme range required in practice; and the results show that the elliptical tube has the advantage in elasticity,—the first inch of deflection requiring only about 30 lbs. pressure, while a total pressure of from 90 to 100 lbs. is sufficient to produce the extreme deflection of about 3 ins. in any direction; up to this pressure there is no permanent set, and consequently no fear of the tube collapsing in any part. The experiments have been extended with the elliptical tube up to  $3\frac{1}{2}$  inches movement in any direction, giving a total range of 7 inches, up to which the tube may be strained safely; beyond this limit a permanent set is produced. In practice, however, the total range in any direction never exceeds 5 inches, or  $2\frac{1}{2}$  inches on each side of the central position,—leaving a sufficient margin of elasticity



to prevent injury to the tube. With a thinner tube or one coiled to a larger circle, an increased range could be obtained if desired.

The connecting tube is attached to both engine and tender by means of the ordinary screw and tail pipe couplings, the tail pipes being brazed upon the circular ends of the tube. It is placed above the axle, and suspended to the foot plate by short chains, so that the wheels can be removed without interfering with the feed-pipe connexion, and it is less liable to damage, should the engine get off the rails, than the ordinary ball-and-socket couplings. The connecting tube is placed central in the engine, whenever practicable, so that the angular deflection produced in running round curves is reduced to the minimum; but it can be fixed without any practical objection, in the usual side position of the feed-pipe, so as to admit of ready application to existing engines and tenders.

This connexion has been fitted to a number of locomotives on the Scottish Central Railway, including some large goods engines; and it has been subjected to severe tests during the last twelve months, and has given every satisfaction. In the engines on this railway the plan of coupling between the engine and tender, drawing as well as buffing on a heavy laminated spring, allows more movement than is usual, amounting to a play of 2 ins. between the engine and tender, and the connecting tube is 6 inches out of the centre; but even under these conditions no failure of the connecting tube has occurred. The dimensions of the engine to which it has been longest attached are—diameter of cylinder, 16 inches; stroke, 20 inches; driving wheel, 6 feet diameter; steam pressure in boiler, 130 lbs. per square inch, and boiler supplied with one No. 9 injector; and the connecting tube has now been continuously working upon this engine for nearly twelve months, with complete success, the engine having run about twenty thousand miles during the time. This tube was taken off the engine, and exhibited to the meeting: it was of circular section, and simply secured with soft solder, and no sign of its giving way was perceptible, thus proving that it is fully equal to its work. A specimen was also exhibited of a connecting tube of oval section, used on large coupled engines; in its manufacture, the tube is swaged oval in proper cresses, and is then filled with resin, and coiled to the required circle round the cast iron blocks used for blocking tyres.

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Mr. Sampson Lloyd believed a somewhat similar plan of coupling had been tried on the South Western Railway, but did not know whether it had been successfully carried out on that line.

Mr. D. Joy thought the new coupling was the best connexion he had seen, and much superior to either the ball-and-socket coupling or the flexible hose pipes.

The Chairman inquired what was the cost and durability of the ordinary hose pipes.

Mr. D. Joy said the flexible hose pipes of canvass and india rubber were the simplest connexion, and cost only about 7s. 6d. each; but their durability was very uncertain; they lasted twelve months with

proper care, if made of good material, but sometimes failed in a single month. He thought the coupling now shown seemed as good in simplicity, and was much superior in durability; and it had an advantage in being placed close up under the foot plate, where it would be out of the way of injury if the engine got off the rails.

Mr. J. Murphy suggested that an iron tube might be used as cheaper than brass or copper.

Mr. D. Joy thought the extra cost of the brass or copper tube would be saved in the manufacture, from the greater ease of manipulation compared with iron, the total weight of metal being so small; an iron tube would also be more rigid, while the greater elasticity of brass or copper would increase the durability of the coupling.

### *Serrin's Automatic Electric Light.*

From the London Athenaeum, August, 1862.

The very ingenious automatic electric light, invented by M. V. Serrin, of Paris, exhibited among the *Instruments de Precision*, in the French Department of the Exhibition, has been shown under various phases at the Polytechnic Institution. The great difficulty in an electric light is to maintain a constantly equal distance between two charcoal points. This is effected by M. Serrin's system, and the result is a steady light of great utility. So intense, indeed, and far-reaching is the light, that small print may be read by it at a distance of three miles. M. Serrin's invention has been practically and successfully employed in carrying on railway works in Spain, where, in consequence of the great heat during the day in summer, it is impossible to carry on the works profitably excepting during the cool night hours. The experiments at the Polytechnic Institution, which will, we believe, be repeated, consist in showing the light in an atmosphere of carbonic acid, burning under water, when it is extremely brilliant, and contrasting it with the illuminating power of ordinary candles.

### *Explosions of Copper Gas Pipes.*

From the Lond. Civ. Eng. and Arch. Jour., Oct., 1862.

Dr. T. L. Phipson states that it has been discovered that when gas pipes constructed of copper or bronze have been long submitted to the action of ordinary coal gas an explosive compound of copper and acetylen (one of the many ingredients of coal gas) is formed. When dry, this compound detonates with extraordinary violence as soon as it is rubbed, struck, or heated. Already some accidents have occurred and some workmen have lost their lives while cleaning large copper gas pipes from this circumstance. No such explosive compound appears to be formed when iron or lead are used. It is evident that large copper gas pipes are unsafe, and that some other metal should be substituted for the copper, as the latter may give rise to explosions at any moment. As concerns small pipes constructed of this metal, they

should not be allowed to get foul, and when about to be cleaned hydrochloric acid should be introduced into them for about ten minutes before they are submitted to any heat or friction. Hydrochloric acid decomposes the explosive compound, combines with the copper, and puts the acetylen in liberty. The acid may then be washed out with hot water.

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For the Journal of the Franklin Institute.

*On a New System of Constructing Ships, proposed to be called the Parabolic Construction.* By JOHN W. NYSTROM, C. E.

The construction of ships is yet in an empirical state, with no established rules for laying down the principal lines, but is wholly dependent on skill, experience, and taste of the constructor. In the parabolic construction herein proposed, positive rules are established for the principal lines, as the load water-line, rail in plan, cross-sections, displacement, sheer, &c., that when the lines are laid down by those rules, they cannot be improved by taking in or out a little more or less here or there; the rule makes the lines right. This will enable the young constructor to lay down ship-lines as fine as if made by the most experienced shipbuilder; still he will not be confined to any particular shape or proportion of the vessel, but can vary it according to his own taste and judgment.

The advantage of the parabolic construction is not only in laying down fine lines, but the simple calculations connected with it are of great importance, and enable the constructor, with but few figures, to go to work with the greatest certainty of attaining a correct result, without recourse to trial and error, or comparison with other vessels. All the lines in a ship are combinations of the *circle*, *ellipse*, *parabola*, and *hyperbola*. These lines are derived from the conic sections, where they are curves of the second order, but herein we will employ them to any order whatever. The ordinary formula for a parabola is  $y = \frac{n}{2}px$ , in which  $y$  = ordinate,  $x$  = abscissa, and  $p$  = parameter; the letter  $n = 2$  in the conic parabola; it is called the *exponent*, and denotes the order of the curve. By assuming different values on the exponent  $n$ , different forms of parabolas are obtained. When  $n = 0$  the parabola will be the two sides forming the right angle in a triangle; when  $n = 1$  the parabola will be the hypotenuse in a right-angled triangle; when  $n = 2$  it will be the true parabola in the conic sections; and when  $n = \infty$  the parabola will again become the two sides forming the right angle in a triangle. The circle, ellipse, and hyperbola follow the same law, which enables us to form theoretically any line in the hull of a ship.

Referring to Plate I, figs. 1 and 2 represent parabolas of different orders from 2 to 10, the vertex being at  $o$ ,  $x$  = abscissa, and  $y$  = ordinate. Figure 1 shows load water-lines of vessels of different sharp-

ness, of which the inner one is considered the sharpest form a vessel can have, being a conic parabola with the exponent  $n=2$ . The higher the exponent is, the fuller will the lines be. Figure 2 represents cross-sections of vessels; the inner line is a conic parabola, and the others of higher order, same as in fig. 1. The order of the lines are marked on the drawing. The shading between every other line is to make it more distinct when selecting a desired sharpness. The water-lines and the cross-sections are precisely the same kind of lines; both can be laid down by the same ordinates.

*Letters denote,*

$D$  = displacement of the vessel in cubic feet.

$T$  = displacement in tons of salt water of 35 cubic feet to the ton.

$\mathcal{A}$  = area of the greatest immersed cross-section in square feet.

$\mathcal{O}$  = area of any ordinate cross-section between  $\mathcal{A}$  and the stem or stern.

$L$  = length of the vessel in the load-line.

$l$  = length from  $\mathcal{A}$  to where the parabola meets the centre line.

$l'$  = the whole length from  $\mathcal{A}$  to the stem or stern, including the hollow lines.

$z$  = measure of the hollow lines.

$B$  = breadth of beam in the load-line.

$b$  = half the beam  $B$ .

$d$  = load draft of water, omitting the depth of keel.

$\delta$  = any draft of water corresponding with the displacement  $t$ .

$t$  = displacement in tons at the draft  $\delta$ .

$e$  = depth of centre of gravity of the displacement, under the water-line.

$x$  = abscissa,  $y$  = ordinate.

All linear dimensions are in feet.

$n$  = exponent for the parabola in the load water-line.

$n'$  = exponent for the parabolas in the cross-section  $\mathcal{A}$ .

$n''$  = exponent for the areas of the ordinate cross-sections  $\mathcal{O}$ .

$r$  = index for displacement at different drafts.

$a$  = area of load water-line in square feet.

$k$  = co-efficient for speed and horse power.

$M$  = nautical miles or knots per hour.

$H$  = horse power required for the speed  $M$ .

$A$  = area of the hull of the boat in square feet.

$a'$  = area of the upper deck, or any horizontal section of the hull at  $d'$  feet from the keel.

$d'$  = depth from  $a'$  to the keel.

$\mathcal{A}'$  = area of the greatest cross-section from the keel to  $a'$ , or the depth  $d'$ .

$e'$  = depth of the centre of gravity of the hull from the top of  $d'$ , supposing the hull to be of uniform thickness.

$a$  and  $e$ , see fig. 1.

$m$  = height of metacentre above the centre of gravity of the displacement.

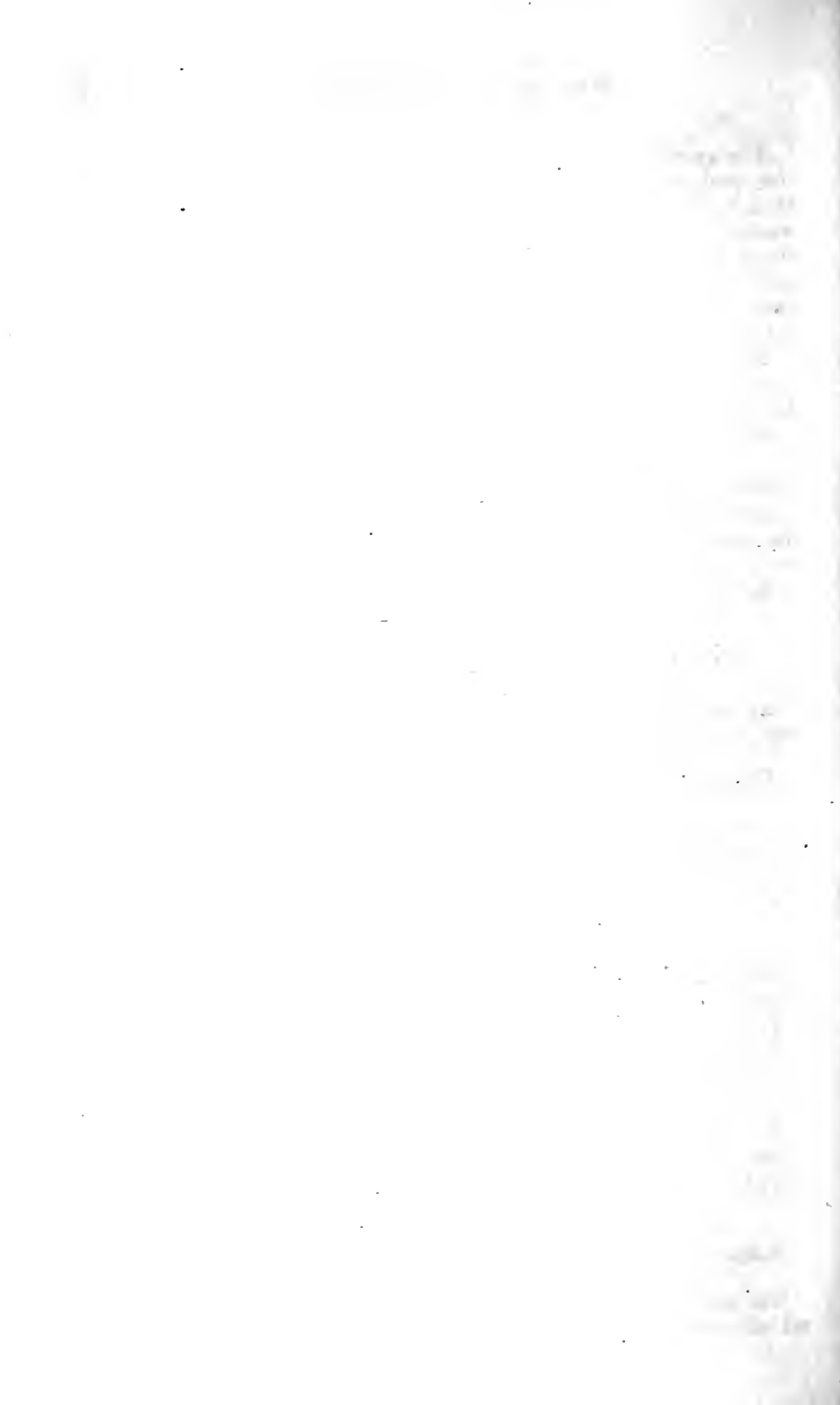
Formulas.

$y = \sqrt[n]{\frac{b}{x}},$	1	$\delta = d \sqrt[n]{\frac{t}{T}},$	13
$x = \frac{y^n b}{l^n},$	2	$t = \frac{\delta^n T}{d^n},$	14
$n = \frac{\log. b - \log. x}{\log. l - \log. y},$	3	$y = \sqrt[n]{b^n - \left(\frac{b x}{l}\right)^n},$ Ellipse,	15
$\mathfrak{O} = \mathfrak{N} \frac{x^2}{b^2},$	4	$l' = l \left( 2^n \sqrt[n]{\frac{b-z}{b}} - \sqrt[n]{\frac{b-2z}{b}} \right),$	16
$a = \frac{n \text{ B L}}{n+1},$	5	$l = \frac{l'}{2^n \sqrt[n]{\frac{b-z}{b}} - \sqrt[n]{\frac{b-2z}{b}}},$	17
$n = \frac{a}{\text{B L} - a},$	6	$c = l \left( 1 - \sqrt[n]{\frac{b-z}{b}} \right),$	18
$\mathfrak{N} = \frac{n' \text{ B } d}{n' + 1},$	7	$a = l' + c - l,$	19
$n' = \frac{\mathfrak{N}}{\text{B } d - \mathfrak{N}},$	8	$A = 2 \sqrt[n'+1]{\frac{n'}{n+1}} \left( \mathfrak{N}' + d' \text{ L} \right) + a',$	20
$D = \frac{n' \mathfrak{N} \text{ L}}{(n''+1) \left( 1 + \frac{1}{2 n''} \right)},$	9	$H = \frac{M^3 \mathfrak{N}}{k \text{ L}},$	21
$n'' = \frac{\log. b - \log. b \sqrt[n'']{\frac{\mathfrak{N}}{\mathfrak{N}}}}{\log. l - \log. y},$	10	$M = \sqrt[k]{\frac{k \text{ L } H}{\mathfrak{N}}},$	22
$e = \frac{d(n'+1)}{2(n'+2)} \sqrt[n'+2]{\frac{n'+1}{n+2}},$	11	$m = \frac{B^3}{12 \mathfrak{N}^3} \sqrt[n]{\frac{D}{\text{L } \mathfrak{N}}},$	23
$r = \frac{(n'+1)(n+1)}{n' n''},$	12	$m = \frac{B^3}{12 \mathfrak{N}^3} \sqrt[n]{\frac{n}{(n+1) \left( 1 + \frac{1}{2 n''} \right)}},$	24
$n'' = \frac{1}{\mathfrak{N} \text{ L} + D} \left( \sqrt{\mathfrak{N} \text{ L } D + 0.4375 D^2} - 0.75 D \right),$			25
$e' = \frac{d'(d' \text{ L} + a + \mathfrak{N})}{2 d' \text{ L} + a + 2 \mathfrak{N}} \left( \frac{n'+1}{n'+2} \sqrt[n'+2]{\frac{n'+1}{n+2}} \right),$			26

TABLE I.

Exp. <i>n</i>	ORDINATES AND CROSS-SECTIONS.								Area <i>w</i> L sq. ft.		Cent. grav. <i>c</i> .		Exp. <i>r</i> .	
	1	2	3	4	5	6	7	8	Disp. cub. ft.		Disp. tons.		Coef. <i>k</i> .	
<b>2</b>	{ 2345 0546	{ 4375 1914	{ 6094 3713	{ 7500 5625	{ 8593 7384	{ 9375 8909	{ 9814 9688	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -6666 <i>N</i> L = -5333 <i>N</i> L		<i>e</i> <i>T</i> = -325 <i>d</i> = -0152 <i>N</i> L		<i>r</i> <i>k</i> = 2.25 = 1.94	
<b>2</b> <sup>1</sup> <b>2</b> <sup>2</sup>	{ 2838 0505	{ 5129 2512	{ 6912 4778	{ 8232 6777	{ 9139 8352	{ 9687 9383	{ 9944 9889	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -7142 <i>N</i> L = -5952 <i>N</i> L		<i>e</i> <i>T</i> = -343 <i>d</i> = -0170 <i>N</i> L		<i>r</i> <i>k</i> = 2.00 = 2.00	
<b>3</b>	{ 3301 1090	{ 5781 3342	{ 7558 5713	{ 8750 7667	{ 9472 8972	{ 9844 9691	{ 9980 9960	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -7700 <i>N</i> L = -6129 <i>N</i> L		<i>e</i> <i>T</i> = -358 <i>d</i> = -0184 <i>N</i> L		<i>r</i> <i>k</i> = 1.77 = 1.94	
<b>3</b> <sup>1</sup> <b>3</b> <sup>2</sup>	{ 3733 1394	{ 6316 4027	{ 8070 6512	{ 9116 8310	{ 9677 9365	{ 9922 9815	{ 9993 9986	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -7777 <i>N</i> L = -6806 <i>N</i> L		<i>e</i> <i>T</i> = -370 <i>d</i> = -0194 <i>N</i> L		<i>r</i> <i>k</i> = 1.71 = 1.88	
<b>4</b>	{ 4138 1712	{ 6836 4673	{ 8474 6858	{ 9375 8789	{ 9802 9608	{ 9961 9922	{ 9997 9991	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -8000 <i>N</i> L = -7111 <i>N</i> L		<i>e</i> <i>T</i> = -381 <i>d</i> = -0203 <i>N</i> L		<i>r</i> <i>k</i> = 1.56 = 1.82	
<b>5</b>	{ 4871 2373	{ 7627 5817	{ 9016 8183	{ 9687 9384	{ 9926 9853	{ 9990 9980	{ 9999 9998	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -8333 <i>N</i> L = -7575 <i>N</i> L		<i>e</i> <i>T</i> = -397 <i>d</i> = -0216 <i>N</i> L		<i>r</i> <i>k</i> = 1.44 = 1.70	
<b>6</b>	{ 5512 3028	{ 8320 6757	{ 9404 8844	{ 9843 9688	{ 9972 9944	{ 9997 9995	{ 1.0000 9999	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -8666 <i>N</i> L = -7912 <i>N</i> L		<i>e</i> <i>T</i> = -409 <i>d</i> = -0226 <i>N</i> L		<i>r</i> <i>k</i> = 1.36 = 1.58	
<b>8</b>	{ 6564 4309	{ 8989 8080	{ 9767 9540	{ 9960 9920	{ 9996 9992	{ 9999 9998	{ 1.0000 1.0000	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -8888 <i>N</i> L = -8155 <i>N</i> L		<i>e</i> <i>T</i> = -426 <i>d</i> = -0233 <i>N</i> L		<i>r</i> <i>k</i> = 1.26 = 1.34	
<b>10</b>	{ 7369 5430	{ 9437 8906	{ 9909 9819	{ 9990 9980	{ 9999 9998	{ 1.0000 9999	{ 1.0000 1.0000	<i>b</i> <i>N</i>	<i>a</i> <i>b</i> = -9090 <i>N</i> L = -8666 <i>N</i> L		<i>e</i> <i>T</i> = -458 <i>d</i> = -0248 <i>N</i> L		<i>r</i> <i>k</i> = 1.21 = 1.18	







*Explanation of Formulas.*

The parabolic formulas 1 and 2 are for calculating the curvature of the load water-line and cross-section. The abscissa  $x$ , subtracted from  $b$ , gives the ordinate from the centre line of the vessel to the water-line or cross-section. Formula 3 is for finding the exponent of the water-line. Formula 4 gives the ordinate immersed cross-sections between  $\mathfrak{X}$  and the stern or bow. In the accompanying table ordinates and cross-sections are calculated for eight places between  $\mathfrak{X}$  and the stem or stern, numbered as shown in the table, and figures 1 and 2.

*Example 1.* Required the fourth ordinate of a water-line with the exponent  $n=3$  and  $b=18$  feet. See table, exponent 3, line  $b$  in the 4th column. Ordinate  $0.8750 \times 18 = 15.75$  feet, the answer.

*Example 2.* Required the area of the 3d, for the exponent  $n''=4$ ,  $\mathfrak{X}=455$  square feet. See table, exponent 4, line  $\mathfrak{X}$ , 3d column.  $\mathfrak{O} = 0.6858 \times 455 = 312.1$  square feet, the answer.

The exponent  $n$  need not be alike, fore and aft, but  $n''$  must be the same, so that the area  $\mathfrak{O}$  be equal for the same number of ordinates fore and aft of  $\mathfrak{X}$ . This rule should be carefully observed.

*Example 3.* Required the area of the load water-line of a vessel  $L=255$  feet,  $B=28$  feet, and the exponent  $n=3\frac{1}{2}$ ?

$$\text{Formula 5. } a = \frac{3.5 \times 28 \times 255}{3.5 + 1} = 5553.3 \text{ square feet.}$$

*Example 4.* The greatest immersed cross-section  $\mathfrak{X}=307$  square feet,  $B=32$  feet, and  $d=12$  feet. Required the exponent  $n''$ ?

$$\text{Formula 8. } n' = \frac{307}{32 \times 12 - 307} = 4, \text{ the answer.}$$

*Example 5.* A ship of  $\mathfrak{X}=307$  square feet,  $L=250$  feet long, and the exponent  $n''=4$ . Required the displacement  $D$  in cubic feet?

$$\text{Formula 9. } D = \frac{4 \times 307 \times 250}{(4+1) \left( 1 + \frac{1}{2 \times 4} \right)} = 54577 \text{ cubic feet.}$$

*Formula 25* is for finding the exponent  $n''$  when  $\mathfrak{X}$ ,  $D$  and  $L$  are given.

*Formula 10* is for finding the exponent  $n''$ , when  $\mathfrak{X}$ ,  $\mathfrak{O}$ ,  $l$ ,  $b$ , and the distance  $y$  between  $\mathfrak{X}$  and  $\mathfrak{O}$  are given.

The formulas 3, 6, 8, 10, and 25 will give the exponents for any vessel.

*Example 6.* A vessel of  $d=12$  feet draft of water (depth of keel omitted), constructed with the exponents  $n=3$ ,  $n'=6$  and  $n''=3$ . Required the depth of the centre of gravity of displacement under water-line?

$$\text{Formula 11. } e = \frac{12}{2} \left( \frac{6+1}{6+2} \right) \sqrt{\frac{3+1}{3+2}} = 4.695 \text{ feet.}$$

The centre of gravity of the displacement in the length of the vessel will always be halfway between  $\mathfrak{X}$  and the middle of  $L$ .

*Example 7.* A vessel constructed with the exponents  $n=2\frac{1}{2}$ ,  $n'=4$  and  $n''=2\frac{3}{4}$ . The load draft of the vessel is  $d=16$  feet, when the displacement  $T=4500$  tons. Required her displacement  $t=?$  at  $d=9$  feet draft.

$$\text{Formula 12. Index } r = \frac{(4+1)(2\cdot5+1)}{4 \times 2\cdot75} = 1\cdot59.$$

$$\text{Formula 14. } t = \frac{9^{1\cdot59} \times 4500}{16^{1\cdot59}} = 1432 \text{ tons, the answer.}$$

The launching draft is calculated by the formula 13, when  $t$  = weight of the vessel in tons.

The formula 15 is for calculating the elliptic form of the stern-rail or deck; its nature is the same as that of the parabolic formula 1, namely, the higher the exponent is, the fuller will the line be.

Ordinates for ellipses of different orders from 2 to 4, are calculated and contained in the accompanying Table II. Half the greatest rail-beam multiplied by the tabular number, gives the corresponding ordinate in the stern-rail ellipse.

See fig. 8, where the stern-rail is an ellipse of the third order or  $n=3$ .

TABLE II. *Elliptic Stern of Vessels.*

Expo't. $n$	ORDINATES FOR ELLIPSES OF DIFFERENT ORDER.							
	$\frac{1}{2}$	1	2	3	4	5	6	7
2	·3398	·4840	·5616	·7808	·8660	·9204	·9682	·9922
$2\frac{1}{2}$	·4108	·5490	·7147	·8274	·9004	·9495	·9801	·9958
$2\frac{1}{2}$	·4670	·5537	·7657	·8627	·9252	·9646	·9873	·9978
$2\frac{3}{4}$	·5174	·6514	·8029	·8901	·9434	·9749	·9932	·9989
3	·5604	·6911	·8331	·9019	·9565	·9821	·9948	·9994
$3\frac{1}{2}$	·5991	·7252	·8578	·9275	·9664	·9871	·9973	·9996
$3\frac{1}{2}$	·6333	·7548	·8782	·9406	·9740	·9907	·9978	·9998
4	·6906	·8021	·9093	·9595	·9840	·9950	·9995	·9999
Sheer of Vessels.	30°	·0149	·0582	·1321	·2374	·3740	·5449	·7531
	45°	·0157	·0539	·1221	·2152	·3517	·5227	·7313
	60°	·0160	·0474	·1086	·1972	·3190	·4794	·6946

*Sheer.* The sheer lines are calculated for circle-arcs of 30°, 45°, and 60°; they will be ellipses of the second order; for 30° the elliptical form is hardly perceptible, but for 60° it is more so.

*Dead Flat.* There is a difference of opinion among shipbuilders as to where to place the *dead flat*  $\Sigma$ . Some place it forward, some abaft, and some in the middle of the vessel. It appears that on sailing vessels the *dead flat* should be located forward, on account of the centre of effort of the sails being high above the ship. In paddle steamers the *dead flat* should be located in the centre, and in propellers abaft the centre. In sailing yachts the *dead flat* is most generally abaft the centre.

The yacht *America*, which won the prize at the exhibition in London in 1851, had her *dead flat* about  $\frac{2}{3}$ ths from the stern. The yacht

*America* is a perfect model of the parabolic construction; her exponents are  $n=n'=2$ , and  $n''=2\frac{1}{4}$ , with no hollow lines.

The clipper ship *Great Republic* had her *dead flat* abaft the centre, and the centre of effort of her sails was about 12 feet ahead of the centre of gravity of her displacement. This is an exceptional case; in sailing vessels the *dead flat* is most generally placed forward of the centre.

*Hollow Lines.* It is the fashion in our days to make the load water-line hollow fore and aft, which fancy is only pleasing and deceiving to the eye. Experiments have been made with a view to find out some less resistance to vessels with hollow lines, but have not, that I am aware of, given any satisfactory results. The hollow lines take away a good portion of the displacement, and diminish the strength and stability of the vessel. In order to follow up the fashion I will here describe how hollow lines are formed in the Parabolic construction. Let *i* fig. 1 be the point where the hollow line is to commence; draw through *i* a line parallel to the centre line, draw the ordinate *z*, find  $z'=z$ , make  $a=a'$ , then *e* is the stem or stern of the boat. Draw equal number of ordinates on *a* and *a'*, by which the line *e' i* is transferred to *i e*, and forms the hollow part of the water-line. The ordinate *z* is the measure of the hollow line, and ought not to exceed  $z=\frac{1}{3}b$ . The formulas 16, 17, 18, and 19, are for calculating different parts connected with the hollow line as will be understood by referring to figs. 1 and 8. Should it be desired to be very fashionable, we can even form a wave-line by the parabolas.

*The Hull of Vessels.* The area *A* of the hull of a boat will be found by the formula 20.

*Example 8.* A vessel constructed with the exponents  $n=n'=4$ ,  $x=307$  sq. ft.,  $d=12$  feet,  $L=250$  feet, and the area of the water-line  $a=5600$  sq. ft. Required the area of the immersed portion of the hull?

$$\text{Formula 20. } A=2\sqrt{\frac{4}{4+1}}\left(307+12\times 250\right)+5600=11516$$

sq. ft. If the vessel is to be coppered add 15 per cent. to the area *A*, and it gives the surface of copper required to cover the immersed portion of the hull, including the lap.

*Example 9.* A vessel of the same dimensions as in the preceding example has the upper deck 8 feet above the load water-line; the beam  $B=28$  feet, makes  $d'=12+8=20$  feet, and  $x=307+28\times 8=531$  sq. feet, area of the upper deck,  $a'=6720$  sq. ft. Required the area of the hull from the keel to the upper deck?

$$A=2\sqrt{\frac{4}{4+1}}\left(531+20\times 250\right)+6720=16614 \text{ sq. ft.}$$

*Example 10.* Suppose the hull of the vessel in the preceding examples to be of  $\frac{1}{2}$ -inch plate iron, and add 15 per cent. to the area *A*, for lap and rivets. Required the weight of the hull in tons, from the keel to the upper deck?

$$A=16614\times 1.15=19106 \text{ sq. feet.}$$

The weight of  $\frac{1}{2}$ -inch iron is 20 pounds per square foot, when the weight of the hull will be

$$\frac{19106 \times 20}{2240} = 171 \text{ tons, nearly.}$$

*Example 11.* Suppose the distance between the frames to be 18 inches or 1.5 feet. Required the length of all the frames to the upper deck? From example 9 we have  $A = 16614$  sq. feet., when the length of the frames will be

$$\frac{16614}{1.5} = 11076 \text{ feet, the answer.}$$

*Example 12.* Required the depth of the centre of gravity in the hull of a vessel with dimensions as in the preceding examples. The exponent for the cross section  $n' = 10$ . The bulwark and keel omitted. Length of upper deck  $L = 262$  feet.

$$\text{Formula 26. } e' = \frac{20(20 \times 250 + 5600 + 531)}{2 \times 20 \times 250 + 5600 + 2 \times 531} \left( \frac{10+1}{10+2} \right) \sqrt{\frac{4+1}{4+2}} = 11.2 \text{ feet.}$$

It will be seen that the *exponents* perform the most prominent part, both in the calculation and construction. By proper selection of the exponents any form of vessels can be constructed by the parabolic method.

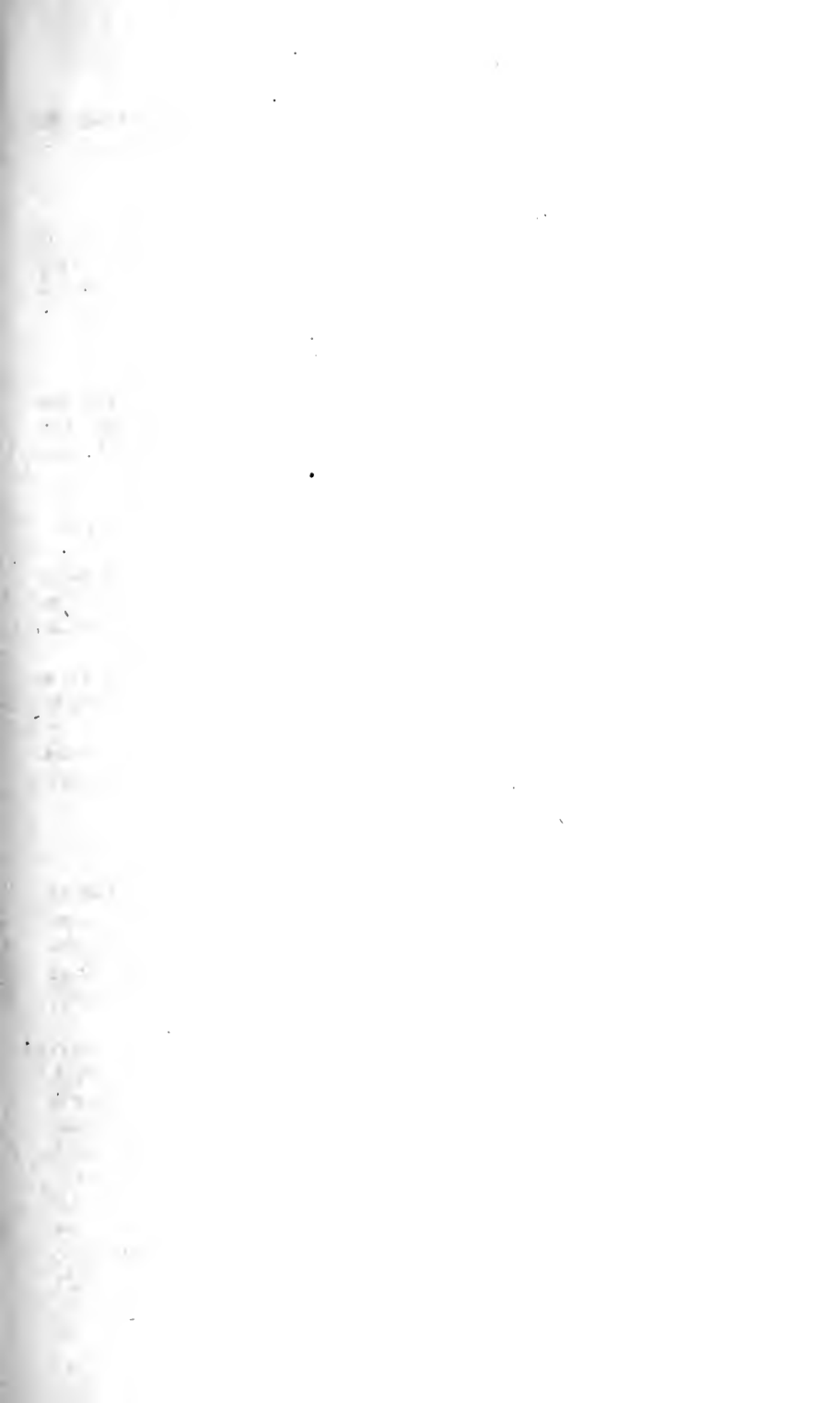
The formula 21 is for calculating the horse power necessary for a given speed; the co-efficient  $k$  will be found in table I. last column, in the line of the given exponent for the displacement.

*Example 13.* What power is required for a vessel of dimensions as in the preceding examples, to propel her  $M = 9$  knots per hour?  $n'' = 4$   $k = 1.82$ ,  $x = 307$  and  $L = 250$ .

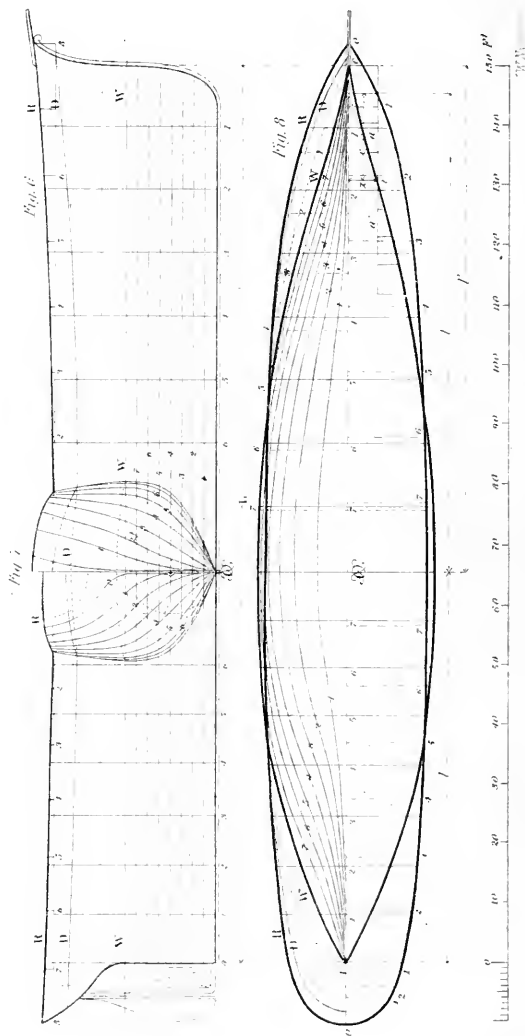
$$\text{Formula 21. } H = \frac{9^3 \times 307}{1.82 \times 250} = 491.8 \text{ horses.}$$

*Figure 3.* Is a scale of displacement at different drafts of water; it is calculated and constructed by the formulas 13 and 14. The numbers on the curves denote the exponent  $n$  of the vessel, and not the index  $r$ . The displacement  $T$  is represented by the 8th water-line from the figure 8 to where it meets the curve; all the other water-lines represent the displacement  $t$  at the noted draft.

*Figure 4.* Is a diagram for laying out the ordinates in the water-line and cross-section; one of these should be constructed for each exponent  $n$ . This diagram is constructed with the exponent  $n = 2$ , the line  $g$   $h = b$ , figs. 1 and 2, and the ordinates in the inner parabola corresponds with the distances from  $g$  in the diagram. It is constructed in the following way: Make a right-angled triangle of any desired size; make the base longer than the height; call the height  $= 1$ ; decide the exponent for the diagram; set off from the right angle the ordinates in the line  $b$  Table I, and join them with the opposite angle in the triangle; then any beam  $b$  set off at right angle from the base to the hy-



# Hydrostatic Construction of Ships



pothenuse gives the corresponding ordinates in the water-line or cross-section.

*Figure 5.* Shows how to lay out the spring of the beams; the length is divided into 8 equal parts from each end, numbered as shown by the figure. The spring of deck beams ought to be a parabola of the second order, when the ordinates are calculated from the line  $b$ , exponent 2, Table I; the spring  $b=1$ .

*Parabolic Construction of a Propeller Steamer. Plate II.*

*Figures 6, 7, and 8* are constructions of a steam propeller of the following dimensions.

$L=150$  feet, length in the load water-line.

$B=30$  feet, breadth of beam.

$d=15$  feet, draft of water, omitting the depth of the keel.

The scale is  $\frac{1}{32}$  of an inch to the foot.

*Figure 8.* The exponents are selected as follows:  $n=2$  of the forward water-line, with hollow lines of  $z=5$  feet, or  $\frac{1}{3}$  of  $b$ ; for the aft water-line;  $n=2\frac{1}{2}$ , with no hollow lines;  $\mathcal{W}$  is located  $\frac{1}{16}$  of the length abaft the middle of  $L$ , making 84.375 feet forward and 65.625 feet aft of  $\mathcal{W}$ . The length  $l$  from  $\mathcal{W}$  to where the parabola meets the centre line is calculated by the formula 17, and found to be  $l=79.9$  feet, which makes the parabola cut the centre line  $84.375-79.9=4.475$  feet from the stem; the length  $l$  is divided into 8 equal parts fore and aft; draw the ordinates, number them, and set off the corresponding distances from the centre line as calculated and contained in the water-line columns, Table III., then draw the water line.

*Hollow Lines.* Find the distance  $c$  by the formula 18, draw the ordinate  $z$  and the parallel line  $a' a$ , transfer the hollow line as before described, then divide the whole length  $l'$  into 8 equal parts for the ordinate cross-sections  $\mathcal{Q}$ .

TABLE III. *Ordinates for a Propeller Steamer.*

Ordi- nates.	Cross. $n'=3$ $\mathcal{W}$	Disp't. $n''=2$ half $\mathcal{Q}$	WATER-LINE.		RAIL.		SHEER.	
			$n=2$ forward.	$n=2\frac{1}{2}$ abaft.	$n=4$ forward.	$n=3$ abaft.	$45^\circ$ forward.	$45^\circ$ abaft.
1	4.951	9.450	3.517	4.257	5.591	9.340	0.047	0.023
2	8.671	33.15	6.562	7.693	9.230	11.24	0.161	0.081
3	11.33	64.50	9.141	10.36	11.44	12.18	0.366	0.183
4	13.12	97.50	11.25	12.33	12.66	12.92	0.645	0.322
5	14.21	128.0	12.89	13.71	13.24	13.26	1.055	0.527
6	14.76	154.0	14.06	14.53	13.44	13.42	1.570	0.785
7	14.97	167.5	14.76	14.91	13.49	13.49	2.195	1.097
8	15 ft.	173.2	15 ft.	15 ft.	13.5 ft.	13.5 ft.	3 ft.	1.5 ft.

The exponent for the cross-section, fig. 7  $n'=3$ , when the area will be formula 7,  $\mathcal{W}=346.5$  square feet; divide the depth  $d$  into 8 equal parts, draw and number the ordinate water lines, set off from the centre line the corresponding distances in the second column, Table III., and draw

the line forming the cross-section; continue it above the water-line according to your own taste and judgment, and the purpose for which the vessel is to be used. It is in this case continued 12 feet to the rail, where the rail beam is  $b=27$  feet. Draw the longitudinal section, fig. 7 with the form of the stem, stern, and sheer; transfer the whole length to the plan fig. 8. The forward rail is a parabola of exponent  $n=4$ , and the aft rail an ellipse of exponent  $n=3$ . Divide the whole length from  $\mathfrak{x}$  fore and aft, into 8 equal parts, draw and number the ordinates as shown by the dotted lines, set off from the centre line the corresponding distances in the rail columns, Table III., and draw the rail. The sheer of the rail is 3 feet on the stem and 1.5 feet on the stern, formed by a  $45^\circ$  curve, Table II., and the ordinate heights in the sheer column, Table III.

*Displacement.* The exponent for the displacement is  $n''=2$ , and the area of half the ordinate cross-sections  $\oslash$  are contained in the third column, Table III. The forth sections fore and aft  $\oslash_4=97.5$  sq. feet, is drawn first, fig. 6; then the second  $\oslash_2=33.15$  sq. feet, and the sixth  $\oslash_6=154$  sq. feet are laid down fore and aft. The ordinate water-lines, fig. 8 are now drawn, after which the remaining cross-sections  $\oslash_1$ ,  $\oslash_3$ ,  $\oslash_5$ , and  $\oslash_7$ , are inserted. In case the ordinate division does not correspond with the frame division, these three sections  $\oslash_4$ ,  $\oslash_2$ , and  $\oslash_6$ , fore and aft may be sufficient to give the form of the boat, after which the regular frame division is made and the frames drawn as in the ordinary construction of ships. There are various modes for calculating the areas of the sections  $\oslash$ , and the most simple and sufficiently correct one is to add the eight ordinates, taking only half of the 8th one, and the sum multiplied by the distance between them, gives the area very near. Another mode more simple and correct, is by an instrument invented by Mr. Amsler, called the *Planometer*, which will be described at the end of this article. The table III. should always be calculated before the construction is commenced.

The displacement is calculated from the formula 9.  $D=27718.267$  cubic feet, and  $T=791.95$  tons.

*Example 14.* The centre of gravity of the displacement is found by the formula 11,  $e=5.04$  feet under the water line, when the medium of the exponent  $n=2\frac{1}{4}$ . In the length the centre of gravity will be

$$\frac{34.375-75}{2} = 4.6875 \text{ feet forward of } \mathfrak{x}.$$

The index for displacement will be,

$$\text{Formula 12. } r = \frac{(3+1)(2\frac{1}{4}+1)}{3 \times 2} = 2.16.$$

Required how much water the vessel will draw with a displacement of  $t=310$  tons?

$$\text{Formula 13. } \delta = 15 \sqrt[2.16]{\frac{310}{792}} = 9.716 \text{ feet, the answer.}$$



The formulas 23 and 24 are for finding the height of metacentre  $m$ , above the centre of gravity of the displacement.

*Example 15.* Required the height of metacentre in the propeller steamer, where  $B = 30$  feet,  $\mathfrak{A} = 346.5$  square feet,  $L = 150$  feet, and  $D = 27718$  cubic feet.

$$m = \frac{30^3}{12 \times 346.5} \sqrt[3]{\frac{27718}{150 \times 346.5}} = 5.266 \text{ feet.}$$

I will avail myself of this opportunity to make a correction in the article on *Stability of Vessels in Water*, published in the last July number of this Journal. There is an error in the formula 1, page 54, which extends through nearly all the examples.

$$\text{Formula 1. } b = \frac{D B^3 \tan. v}{772 L \mathfrak{A}^2}, \text{ should be } = \frac{B^3 \tan. v}{12 \mathfrak{A}} \sqrt{\frac{D}{64.3 L \mathfrak{A}}}.$$

Also, the formula 7, should be

$$\text{col. } v = \frac{D}{W L} \left( \frac{B^3}{12 \mathfrak{A}} \sqrt[3]{\frac{D}{64.3 L \mathfrak{A}}} \pm a \right) = \frac{D}{W L} (m \pm a).$$

In the formula 6, the last term  $b$  should be negative, or  $-b$ .

These corrections are made in the seventh edition of Nystrom's Pocket Book.

By differentiating the formula 14,  $t = \frac{T \partial r}{dr}$ , in which  $T$  and  $d$  are constants,  $t$  and  $\delta$  the variables, we have

$$\delta t = \frac{r T \partial r - 1. \delta \delta}{dr}, \text{ and } \delta \delta = \frac{dr. \delta t}{r T \partial r - 1}$$

$\delta t$  = increment of the displacement, and  $\delta \delta$  = increment of the draft of water.

*Example 16.* It is required to know how much ( $\delta t = ?$ ) the propeller steamer can be loaded per  $\delta \delta = 1$  inch or  $\frac{1}{12}$  foot of additional draft of water, at a draft  $\delta = 12$  feet?

From the preceding examples we have  $r = 2.16$ ,  $T = 792$  tons, and  $d = 15$  feet.

$$\delta t = \frac{2.16 \times 792 \times 12^{2.16}}{15^{2.16} \times 12} = 7 \text{ tons, the answer,}$$

which will sink the steamer one inch.

*Example 17.* The vessel is loaded to a draft of  $\delta = 13$  feet. How much ( $\delta \delta = ?$ ) will the vessel sink by charging her with  $\delta t = 20$  tons more?

$$\delta \delta = \frac{15^{2.16} \times 20}{2.16 \times 792 \times 13^{1.16}} = 0.202 \text{ feet} = 2.284 \text{ inches, the answer.}$$

The principal formulas, tables, and examples of the parabolic construction of ships, are contained in the seventh edition of Nystrom's Pocket Book of Mechanics and Engineering, where there is not room for a complete explanation on the subject.

Displacement.	NAUTICAL MILES OR KNOTS PER HOUR.							
	5	6	7	8	9	10	11	12
T	H	H	H	H	H	H	H	H
100	11.8	19.4	32.4	48.4	68.5	94.5	126	163
200	18.8	32.5	51.5	76.9	110	150	200	260
300	24.5	42.4	67.5	100	142	196	262	340
400	29.8	51.4	81.7	122	172	238	317	412
500	34.6	59.6	94.3	141	200	276	368	478
600	39.0	67.2	107	160	226	313	415	540
700	43.3	74.6	119	177	250	377	460	599
800	47.3	81.5	130	194	274	378	503	654
900	51.1	88.1	140	210	296	409	545	708
1000	54.9	94.6	150	225	318	439	585	759
1100	58.4	100	160	239	338	467	622	806
1200	62.0	107	170	254	359	495	660	858
1300	65.3	112	179	267	378	523	696	903
1400	68.7	119	189	281	398	549	732	950
1500	71.9	124	197	295	417	575	766	995
1600	75.0	130	206	307	435	600	800	1038
1700	78.1	135	215	320	453	625	833	1083
1800	81.2	140	224	332	470	649	864	1123
1900	84.2	145	231	345	488	673	897	1166
2000	87.0	150	239	356	504	696	927	1205
2100	90.0	155	247	369	521	720	958	1247
2200	92.7	160	255	380	537	741	988	1284
2300	95.6	165	262	391	554	764	1017	1324
2400	98.4	170	270	402	569	786	1047	1360
2500	101	174	277	414	585	808	1077	1400
2600	104	179	285	424	600	828	1102	1435
2700	106	184	292	436	616	850	1131	1473
2800	109	188	299	446	631	871	1160	1508
2900	111	192	306	457	646	893	1189	1545
3000	114	197	313	467	660	913	1215	1582
3100	117	201	320	478	676	933	1242	1614
3200	119	205	327	488	690	952	1268	1648
3300	121	209	334	498	704	972	1296	1683
3400	124	214	340	508	718	992	1320	1717
3500	127	218	347	518	733	1010	1347	1750
3600	129	222	354	528	746	1025	1373	1783
3700	131	226	360	538	759	1049	1398	1815
3800	133	230	367	548	774	1070	1422	1848
3900	135	234	373	558	787	1087	1446	1880
4000	138	238	380	567	801	1105	1473	1912
4100	140	242	386	577	814	1122	1497	1944
4200	142	246	392	586	827	1141	1520	1975
4300	145	250	398	595	840	1160	1545	2008
4400	147	254	404	604	853	1179	1568	2037
4500	150	258	410	613	866	1198	1593	2070
4600	152	261	416	622	879	1216	1614	2100
4800	156	270	428	640	904	1248	1663	2160
5000	160	277	440	658	929	1332	1708	2220
5500	171	295	469	700	990	1367	1822	2365
6000	181	303	497	742	1050	1448	1930	2507

Displacement.	NAUTICAL MILES OR KNOTS PER HOUR.							
	13	14	15	16	17	18	19	20
T	H	H	H	H	H	H	H	H
100	207	259	318	387	464	551	648	756
200	329	412	506	615	737	875	1027	1201
300	432	540	662	806	966	1146	1347	1573
400	522	654	803	976	1170	1402	1632	1907
500	607	759	932	1131	1358	1611	1896	2213
600	684	856	1036	1280	1532	1820	2140	2500
700	759	938	1166	1417	1700	2016	2373	2770
800	830	1038	1274	1548	1857	2206	2593	3026
900	898	1123	1380	1675	2009	2385	2803	3274
1000	963	1206	1480	1798	2157	2560	3008	3514
1100	1024	1284	1574	1913	2295	2723	3203	3736
1200	1090	1360	1670	2030	2435	2890	3400	3967
1300	1147	1432	1758	2136	2564	3043	3576	4178
1400	1204	1508	1850	2248	2697	3200	3762	4394
1500	1264	1580	1938	2355	2825	3352	3943	4605
1600	1317	1648	2020	2458	2948	3500	4113	4803
1700	1374	1718	2107	2561	3072	3646	4286	5006
1800	1422	1784	2188	2660	3190	3785	4448	5195
1900	1479	1850	2270	2760	3310	3928	4615	5390
2000	1527	1913	2345	2854	3420	4060	4770	5570
2100	1582	1979	2382	2948	3535	4195	4935	5762
2200	1628	2037	2500	3038	3642	4325	5081	5935
2300	1680	2102	2578	3134	3755	4460	5241	6120
2400	1723	2160	2646	3220	3860	4580	5386	6290
2500	1777	2222	2725	3313	3970	4715	5542	6470
2600	1820	2280	2796	3400	4075	4835	5655	6637
2700	1870	2338	2868	3486	4180	4960	5832	6813
2800	1911	2395	2935	3568	4280	5076	5970	6970
2900	1960	2452	3010	3655	4385	5200	6115	7142
3000	2000	2508	3075	3740	4485	5318	6255	7300
3100	2048	2565	3145	3822	4585	5440	6394	7470
3200	2092	2616	3210	3905	4680	5550	6525	7622
3300	2134	2671	3280	3985	4775	5670	6666	7781
3400	2178	2725	3343	4063	4870	5784	6784	7936
3500	2220	2779	3408	4143	4965	5893	6936	8090
3600	2264	2830	3475	4222	5060	6010	7061	8250
3700	2303	2881	3534	4300	5155	6115	7184	8400
3800	2348	2941	3606	4385	5250	6238	7333	8563
3900	2385	2986	3660	4453	5340	6336	7444	8695
4000	2427	3038	3725	4530	5430	6444	7580	8847
4100	2468	3086	3785	4610	5520	6550	7700	8988
4200	2507	3137	3850	4680	5610	6655	7830	9141
4300	2546	3186	3910	4750	5700	6761	7950	9285
4400	2585	3238	3970	4825	5790	6865	8072	9432
4500	2624	3286	4025	4900	5875	6970	8195	9572
4600	2664	3333	4087	4970	5960	7070	8320	9710
4800	2740	3431	4202	5113	6130	7275	8555	9990
5000	2817	3525	4321	5253	6300	7475	8792	10250
5500	3000	3755	4608	5600	6715	7972	8370	10953
6000	3180	3981	4880	5935	7120	8446	9935	11586

*Steamship Performance.*

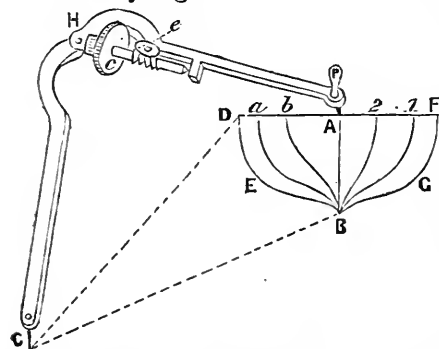
This subject has received a great deal of attention by operative minds, but has not yet been satisfactorily established. We know that the resistance is in proportion to the square of the velocity, multiplied by the area projecting to the motion; that if we know the performance of one vessel, we can easily find the performance of any other vessel of equal proportions; but when this proportion varies, the subject becomes more intricate. We therefore know that the resistance is a function of  $M^2 \mathcal{A}$ , and consequently the power or mechanical effect required to propel the vessel, is a function of  $M^3 \mathcal{A}$ . The displacement  $D$  is a function of the cube of any linear dimension of the same, and the greatest immersed section  $\mathcal{A}$  a function of the square of any linear dimension of the displacement, consequently the  $\sqrt[3]{D}$  is a function of any linear dimension of  $D$ , and  $(\sqrt[3]{D})^2 = \sqrt[3]{D^2}$  is a function of  $\mathcal{A}$ ; therefore the resistance is a function of  $M^2 \sqrt[3]{D^2}$ , and the mechanical effect, which we may call the horse power  $H$ , is a function of  $M^3 \sqrt[3]{D^2}$ . If we know the performance of one vessel to be  $\frac{M^3 \sqrt[3]{D^2}}{H} = c$ , a co-efficient, we can thereby ascertain the performance of any other vessel of the same proportions, or  $H = \frac{M^3 \sqrt[3]{D^2}}{c}$ , and  $M = \frac{\sqrt[3]{H c}}{D^2}$ .

The preceding tables are calculated by these formulas, for vessels of the following proportions:—the length  $L = 6 B$  breadths, and the exponent for the displacement  $n'' = 2\frac{1}{2}$ , which makes a very sharp vessel.

The displacement  $D$  is denoted by the letter  $T$  in tons in the first columns; the speed  $M$  in nautical miles per hour in top line, and the table gives the corresponding horse power  $H$ . The horse power here means the actual power of 33,000 pounds lifted one foot per minute, and not nominal horse power, rated by the dimensions of the steam cylinders.

*Description of Amsler's Planometer, as applied to Shipbuilding.*

This very ingenious and useful instrument seems to be but little



known among engineers and constructors. It is a very important instrument in the construction of ships, where it saves a great deal of time and calculations; by applying the planometer to the frame drawing of a ship, the displacement is obtained correctly with only one multiplication, in a few minutes.

The accompanying figure represents Amsler's Planometer in position to take the areas of the immersed cross-sections of a ship. The instrument rests on

three points, namely, A, C, and  $c$ ; it has a hinge at H; the point  $c$  is stationary when the point P moves about; the wheel  $c$  turns in different directions, indicating the area described by P. The nature of the instrument is such that, when the point P moves from D via A to B, the wheel  $c$  indicates the area of the figure A, B, C, D; if P is moved further from B via E to D, the wheel  $c$  subtracts the area B, C, D, E, leaving indicated the area A B E D. The wheel  $c$ , with the assistance of a vernier, gives three figures in the reading, and the wheel  $e$  moved by a worm-screw gives the fourth figure; the instrument gives a nicety of four figures in the reading, which is sufficient for most practical purposes.

The planometers are always made so that the point P is to be moved with the sun. However irregular a plan-figure might be, the point P moved through the whole boundary, gives the area on the wheels  $c$  and  $e$ . The cross-section A, B,  $b$ , is obtained by moving P in the boundary from A via B,  $b$ , and back to A.

When it is desired to know the area of all the cross-sections, it is not necessary to read off every one of them, but continue to move through all the boundaries and the wheels will add up the whole to one sum, which, multiplied by 2 and the distance between the sections, gives the displacement; though care must be taken not to take the greatest section @ twice. Suppose all the areas of the figure before us is to be taken for the displacement: Move P from A to B  $b$  A, B  $a$  A, B E D A, further from A to 2 B A, 1 B A, and the wheels will show the total sum of half the sections.

Mr. Amsler, formerly a resident of Philadelphia, returned about a year ago to his native country, Switzerland, the only place where the planometer is now manufactured. It is sold by McAllister, Chestnut street, Philadelphia, and by Elliot Strand, London, where more complete descriptions of the instrument can be had.

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For the Journal of the Franklin Institute.

### *Indian Method of Making Fire.*

In the "History of the Manufacture of Instantaneous Light," in the December number of the *Journal*, Prof. Lyon Playfair states that "the savages of various countries found for themselves a means of getting a light which was far from instantaneous. I think that it would require much more dexterity than we can employ to demonstrate how a light may be got by rubbing together two pieces of wood."

Perhaps many of us have tried the experiment with the same success as the lecturer; and as I have never seen published the method by which it is accomplished, the following explanation may not be without interest to your readers:—

I have a pair of the sticks used by the Indians on the Northwest Coast of the United States for obtaining fire; have seen the same sticks in use to produce fire, and have myself produced fire therewith. Each is sixteen inches long; the thicker is three inches in circumference, and has been cut so that a section would give a rough ellipse with the

largest diameter one and one-eighth inch. The smaller is one and three-quarters of an inch in circumference. Both are crooked, just as they grew, and after depriving the smaller of its bark, it was whittled so that a section would give an irregular polygon; this was done for a good reason, as will be apparent. I cannot say what the wood is, but it presents an open network when examined in section; they are apparently of the same kind, but the smaller has more compactness, and shows signs of a slower growth. The Indians always select pieces with that difference. Both have been thoroughly roasted, and were carried carefully wrapped in skin, to prevent the absorbing of moisture; accompanying them is carried a bunch of the inner bark of the cedar, picked very fine and dried.

To use them, the larger has a shallow circular hollow, less than one-eighth of an inch in depth, made on its broad side, near one end, and a narrow groove or channel cut from this to the side; the smaller stick has one end made very slightly rounding. The Indian squats, holds the larger stick upon the ground with his bare feet, and places under the groove a small bunch of the bark fibre. The smaller stick is then held upright, the rounded end placed in the hollow of the larger stick, and with both hands at top and the stick between them, he commences to rapidly revolve it by rubbing the hands upon each other backward and forward, at the same time exerting pressure downward, by which his hands gradually slip down; he dexterously—and this is *the* point of success—runs his hands to the top and repeats the previous operation. A fine brown powder is soon produced by the attrition, and is carried along the side groove among the bark fibre. This powder is finally ignited, and the burning transmitted along the groove to the bunch of bark fibre, which is quickly seized by the operator and blown into a flame.

With the sticks in my possession I have seen them produce a flame in about one minute, and have frequently done so myself in three minutes. In eleven years' experience on the Western Coast, I never saw but this pair of sticks, when we were thrown among a tribe previously unacquainted with white men. The Indians generally used lucifer matches bought from the Hudson Bay Company or trading vessels.

GEORGE DAVIDSON.

Germanatown, Pa., Jan. 18, 1863.

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For the Journal of the Franklin Institute.

### *St. Elmo's Fire.*

JOHN F. FRAZER, LL.D.

DEAR SIR—In accordance with your desire, I have the pleasure herewith to furnish you with an account of my close contact with "St. Elmo's Fire."

About sixteen years ago—being then traveling in Ireland—I left my hotel at Castlederg, County Donegal, to post it to Stranorlar. I started about 5 o'clock in the evening of a lowering and chilly November day. I traveled in a fancy or sporting vehicle known in

Europe as a "tax-cart"—driving a pair of horses tandem fashion, and attended by an hostler from the hotel. As it was yet daylight when we started, we did not light our lamps.

The night soon darkened, and a heavy bank of very dark clouds accumulated in the southwest. As suddenly as a peal of thunder, and almost as loud, a heavy squall burst on us, causing us to hold the horses at a stand still, and shield our faces from the fury of the blast and of the cutting hail that accompanied it.

After a few minutes the squall had so far abated as to permit us to look up. The first thing I observed on lifting my head, was the whip in the hostler's hand, covered with a pale flame, from the point to about twenty-five or thirty inches down the handle. Almost at the same instant I observed the rim of the hostler's hat, as also of my own, encircled with similar flames. An involuntary impulse led me to snatch the whip out of the hostler's hand, who, poor fellow, was completely paralyzed with terror, and drawing it through my hand, which was covered with a thick leather riding glove, the flame attached itself partly to the glove and blazed for a few seconds, till I brushed it off with the other hand. I then drew my fingers along the rim of my hat, where the flame continued. The fingers, in passing over it, extinguished it while passing, but it immediately re-appeared, although to a less extent than at first.

The flame appeared to blaze up from one to two inches from the whip handle, and had that peculiar lapping sound made by the flame of melted sulphur when blown upon. I did not perceive any peculiar odor, although such might have existed, as my attention was directed altogether to the strange, and, as I supposed, threatening phenomenon with which I was so suddenly brought into contact.

The road was a strange one to me, and it being night, I could not then observe the character of the country; but I subsequently traveled over the same road by day, and found the country to be bare, open, and somewhat hilly; no trees to speak of, and no bogs—at least none that I could discover on the line of road.

The character of the weather after the squall was rather tempestuous, with occasional flashes of lightning, although I did not observe any during the squall.

I am, dear sir, yours truly,

GEORGE MILLIKEN.

828 Arch street, Philadelphia, 24th October, 1862.

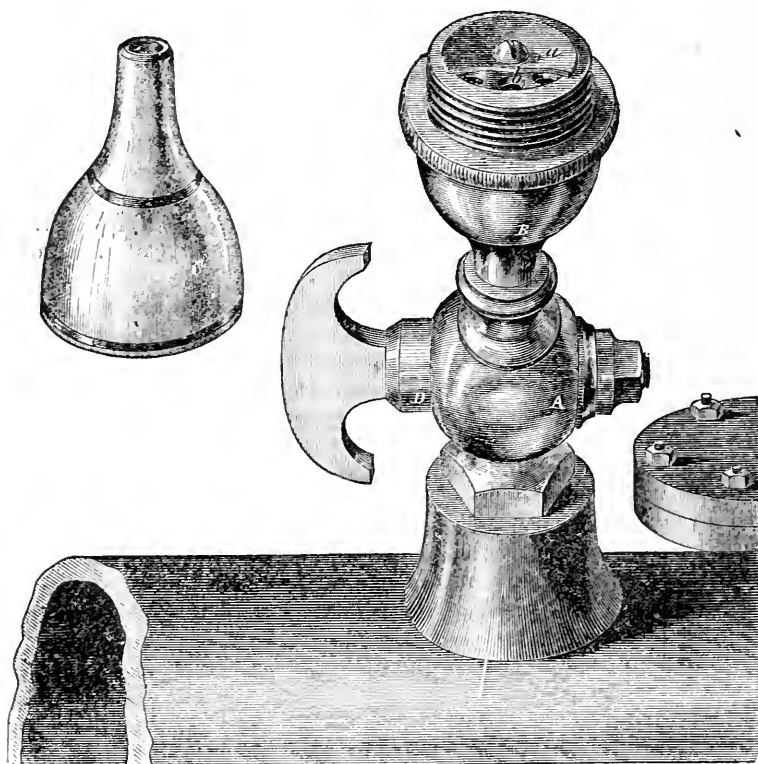
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For the Journal of the Franklin Institute.

*Description of an Improved Mode of Exhausting Air from Pumps.*  
*Patented by THOMAS SHAW, of Philadelphia, Penna.*

The operation of Pumping is often impeded by the ingress of air, or the generation of vapor; an evil which becomes very great when feeding steam boilers under *high pressure*. The air or vapor alternately expands and contracts with the stroke of the pump, not permitting sufficient water to enter to lift up the check-valve. The ordinary method of exhausting this air or vapor is, by an ordinary stop-

cock ; a very imperfect method, as the air is alternately drawn in and forced out with the stroke of the pump, and where the pump has to lift its water, is totally ineffectual. It is common for engineers to place their thumb over the orifice of the common faucet, and thus make a temporary valve to start the pump ; or, by alternately turning on and off the stop-cock at each stroke of the pump. Although this imperfect method may answer for a single operation, there is no more cause for an engineer to become part of the valve arrangement of the pump, than for his becoming part of the valve gear of his engine, as was once the case, as the annexed engraving represents a simple device for the accomplishment of the above difficulties.



A represents an ordinary stop-cock, to which is attached a hemispherical top, B, having on its upper side a rubber valve, a, a portion of which is removed to expose the apertures beneath, which the said valve covers. The valve is protected and finished by screwing the cap, c, over the top of B. When the pump becomes inoperative because of air or vapor, the plug, D, of the stop-cock is turned, when the air or vapor makes its exit by lifting the valve, a, after which the valve closes and prevents any return of the same.



*On Webster's Method of Preparing Oxygen Gas from a Mixture of Nitrate of Soda and Oxide of Zinc.* By JOHN HENRY PEPPER, Esq., F. C. S., A. Inst. C. E., Professor of Chemistry, and Hon. Director of the Polytechnic Institution.

From the London Chemical News, No. 152.

The statement, that large quantities of oxygen gas could be quickly and easily procured from a mixture of one part, by weight, of nitrate of soda, and two parts of crude oxide of zinc, obtained from the (so-called) galvanizing zinc-pots or baths of Birmingham and other places, appeared so doubtful, that, prior to the introduction of the new process at the Polytechnic, I was induced to visit Mr. Webster and his co-patentee, Mr. John H. Porter, at Bent's wharf, Cannon Row, Westminster, in order to investigate practically the working of this new mode of making oxygen gas.

The apparatus, arranged for the manufacture of oxygen and other products, consists of a circular, portable, iron, fire-brick lined furnace, containing an inner, strong, cast-iron vessel, 10 inches in diameter, furnished with a cover and iron tube; into this is placed a second cylindrical iron pot or retort, of 7 ins. diameter, open at the top, and provided with an orifice at the base, temporarily stopped with a piece of sheet iron, so that, when the materials used are exhausted, the inner pot can be removed, and the contents easily knocked out with an iron bar; and as the product left after the disengagement of the gas is not allowed to fuse, and only becomes slightly coherent or pasty, this cylindrical form of retort, open top and bottom, and placed in an outer vessel of iron, which can be properly closed by a luted cover, answers remarkably well, and may be used by any intelligent workman. In connexion with the outer iron vessel is a  $1\frac{1}{2}$ -inch iron pipe luted into a stoneware tube, forming part of, and leading to the bottom of a 30-gallon stoneware vessel, containing half a gallon of water (5 lbs.), and eight movable stoneware, colander-like shelves; upon these are placed 48 lbs. of residue, which have been taken out of the retort after a former experiment, *i. e.*, when the oxygen has been obtained from it. This residue, or *caput mortuum*, consisting (as will be noticed more particularly in another part of this paper) of oxide of zinc, caustic soda, nitre, nitrite and nitrate of soda, &c., is moistened with half a gallon of water, and carefully placed on the shelves, which are fitted in one after the other, commencing at the bottom of the vessel. The purifier, thus arranged, is furnished with a lid dropping into a water-joint, and the whole connected with a sheet iron gasometer, painted inside and out, and having a sectional area of 28.2744 feet, making the cubical contents per vertical inch 2.3562 c. i.

As the success of the process, so far as the maximum of oxygen is concerned, depends greatly on the thorough dryness of the materials used, 12 lbs. of nitrate of soda were dried on a hot plate forming the top of the circular iron furnace, and 24 lbs. of oxide of zinc were made red-hot in the retort; the loss of weight by this method of drying was very slight, and did not exceed an ounce or so in either case.

Ten pounds of the dry and warm nitrate of soda, and 20 lbs. of the dry and warm oxide of zinc, were then roughly mixed together in an iron tray, and dropped through an iron funnel into the inner red-hot retort, which could be easily lifted in or out of the exterior one by means of a chain and little crane attached to the furnace.

The cover, provided with a hole at the top, was then luted on with a mixture of Stourbridge clay and sand, and in about a minute or so the nitrate of soda gave off oxygen, colored with the orange-red fumes of nitrous acid: the top aperture was now closed, and the connexion with the purifier and gasometer opened at 1.30 P. M.

The following columns show the rate at which the gas was made, although it is right to state that the gas comes over frequently much faster:—

Time.	Vertical Inches, equal to 2.3562 Cubic Feet.									
1.30										
1.35	.	.	.	.	.	.	.	.	.	1.50
1.40	.	.	.	.	.	.	.	.	.	1.90
1.50	.	.	.	.	.	.	.	.	.	2.30
2.00	.	.	.	.	.	.	.	.	.	3.00
2.10	.	.	.	.	.	.	.	.	.	4.30
2.30	.	.	.	.	.	.	.	.	.	6.75
2.40	.	.	.	.	.	.	.	.	.	8.50
2.50	.	.	.	.	.	.	.	.	.	9.75
3.00	.	.	.	.	.	.	.	.	.	11.00
3.10	.	.	.	.	.	.	.	.	.	12.00
3.20	.	.	.	.	.	.	.	.	.	13.00
3.30	.	.	.	.	.	.	.	.	.	13.30
3.45	.	.	.	.	.	.	.	.	.	14.00
4.00	.	.	.	.	.	.	.	.	.	14.30

$$2.3562 \times 14 \text{ vertical inches} = 33.968 \text{ cub. feet.}$$

Directly the gas ceased to come over, the valve in connexion with the gasometer was turned off, and the inner retort being lifted out with the contents (the residue or *caput mortuum* already mentioned), and weighed, was found to have lost 5.5 lbs. After knocking out the residue, the retort was again quickly charged, at 4h. 5m. P. M., with a fresh mixture of 10 lbs. nitrate of soda, and 20 lbs. of oxide of zinc, which gave off the whole of the gas by 6h. 30m. P. M.

The gas amounted to 14.3 vertical inches—

$$14.3 \times 2.3562 = 33.69 \text{ cubic feet,}$$

and the loss of weight of the materials used was again found to be 5.5 lbs. The residue in the purifier having now been used for these two charges, was taken out, and it weighed 2 lbs. heavier than before, in consequence of its having absorbed nitric acid. The residue was then digested with the whole of the weak nitric acid which had been absorbed by the half-gallon of water placed at the bottom of the purifier (the whole weight of the acid being about 11 lbs.), and when perfectly dried and warm it weighed 48 lbs. It was then placed in the retort and lost 4 lbs., producing (according to Mr. Webster, who watched the operation to the end) 28 cubic feet of gas—thus showing that when 50 lbs. of refuse material out of the retort are used to purify the gas from 20 lbs. of nitrate of soda, the nitric acid obtained during the process is retained, partly by the solid substance, and

partly by the water in the purifier, and that, if the whole is then mixed, digested, dried, and subsequently heated in the retort, it will give out almost as much gas (28 cubic feet) as 10 lbs. of fresh nitrate of soda (33 cubic feet).

The 50 lbs. of residue were procured after heating a mixture of 20 lbs. of nitrate of soda and 40 lbs. crude oxide of zinc; so that the quantity of gas obtained by this plan from 20 lbs. of nitrate of soda, and using the nitric acid, amounts to—

1st charge of 10 lbs. nitrate of soda and 20 lbs. crude oxide of zinc, .	Cubic feet.
2d ditto, ditto, . . . . .	32.986
3d. Material out of purifier, after being used to absorb the nitric acid produced from Nos. 1 and 2, . . . . .	33.69
	28.00
Total cubic feet, . . . . .	94.676

Theoretically, and supposing the 20 lbs. of nitrate of soda were chemically pure, and decomposed into oxygen and nitrogen, leaving a residue of soda, the loss should be 12.82 lbs.; the loss was, however,  $5.5 \times 2 = 11$  lbs. The nitrate of soda used was the ordinary commercial article, and contains  $2\frac{1}{4}$  per cent. of chloride of sodium.

The gas obtained from the nitrate of soda and oxide of zinc was analyzed by the phosphorous method, and also by the usual hydrogen mixture fired by the electric spark in Ure's syphon eudiometer, and gave, as the mean of several experiments, 59 volumes per cent. of oxygen gas, and 41 volumes per cent. of nitrogen.

94.676 cubic feet of gas, therefore, contain—

55.858 cubic feet of oxygen* =	lbs. oz.
38.818 cubic feet of nitrogen =	4 11
Nitric acid and loss	2 13
	3 8
	11 0

The nitric acid appears to be formed during the first stage of the process, when the materials thrown into the red-hot retort are comparatively cold, and evolve nitrous acid  $\text{NO}_3$ , and oxygen; these gases, in the presence of the moisture of the purifier, form nitric acid, and it is very likely that when a second and smaller red-hot iron vessel, containing oxide of zinc, or, still better, oxide of copper, is connected with the first iron retort, any acid produced during the process would be decomposed perfectly by the second red-hot surface, and, even if nitrate of zinc or copper were formed, it would be ultimately decomposed into nitrogen, oxygen, and oxide of copper. The experiment again, twice repeated, afforded nearly the same results:—

Experiments.	Nitrate of Soda.	Oxide of Zinc.	Loss.	Cubic feet of Gas.
No. 1,	10 lbs.	20 lbs.	5.25	37
No. 2,	10 "	20 "	5.25	32
2	20 lbs.	40 lbs.	10.50	69

In order to ascertain how often the same 20 lbs. of oxide of zinc could be used with separate additions of 10 lb. charges of nitrate of

* Weight of a cubic foot of oxygen, at a temperature of 60°, barometer 30 inches, . . . . .	Grains.
Weight of a cubic foot of nitrogen, at same temperature and pressure, . . . . .	590.8
	517.7

soda, three experiments were tried, as tabulated below, it being understood that the second 10 lbs. was not added until the first had evolved its gas, and so on with the third 10 lbs.

Nitrate of Soda.	Oxide of Zinc.	Residue.	Loss.	Gas, Cubic feet.	Nitric Acid in solid contents of purifier 56 lbs.	Nitric Acid absorbed by water in purifier.
10	20	25.5	4.5	49.47	2 lbs.	3lb. + water 5
10	—	30.0	5.5	47.12	increase in weight.	total 8lbs.
10	—	36.25	3.75	47.12		Sp. gr. 1.136
30	20	36.25	13.75	143.71	2 lbs.	8lbs. s.g. 1.136

These experiments were performed between 1 P. M. and 10 P. M., and it is evident that there is a great increase of gas, and a reduced proportion of nitric acid. It may be noticed as a proof the rapidity with which oxygen is prepared by this process, that with a small apparatus only capable of containing the three charges above mentioned, it produced 143.71 cubic feet of gas (containing 59 per cent. of oxygen) in nine hours, or nearly 16 cubic feet per hour.

If the apparatus had been large enough to contain more materials, there is no doubt that the same 20 lbs. of oxide of zinc would have done with one or two more separate 10 lb. charges of nitrate of soda.

The oxide of zinc probably acts mechanically (like oxide of manganese with chlorate of potash), and also chemically, as a carrier of nitric acid. When the nitrate of soda is heated, it gives off nitric acid, which is probably taken up by the oxide of zinc, and again decomposed (as the temperature rises) into oxygen and nitrogen: and, as before stated, if a second small red-hot vessel, containing oxide of copper or zinc, was attached to the retort, the whole of the nitric acid would probably be decomposed, and an increased proportion of oxygen obtained.

In order to form some notion of the value of the gas as a means of increasing artificial light, a peculiar shaped Bude Light burner, consuming coal-gas instead of oil, was experimented with.

The burner, with oxygen admitted to the centre of the flame, consumed, according to an experimental meter made by Brown and Bischoff, 4.2 cubic feet of coal gas, and 5.3 cubic feet of the oxygen gas per hour, and produced a light equal to 36.7 Parliamentary candles, consuming 120 grains per hour.

The same quantity of coal gas, per hour, burnt in a 36-hole Argand burner, with a chimney  $9\frac{1}{2}$  inches high, gave a light equal to 10.1 candles.

The light obtained from the coal gas and oxygen was exceedingly bright and white, both gas and candle-light looking yellow by the side of it.

The cost of the coal gas alone, to produce the same light, would be about equal to that of the extra oxygen used; but the purity of the light, and the saving of gas burners and fittings, by using oxygen and coal gas, increase the value of the combined arrangement.

To ascertain the composition of the residuum, weighing 36 lbs. 4 oz. (left in the retort after the three experiments, in which the same oxide of zinc was used three times), it was digested with plenty of water, and the insoluble oxide of zinc separated by a calico filter, and this, when washed and dried, weighed 23 lbs. 12 oz.

The filtrate and washings, evaporated to dryness in an iron vessel, weighed 15 lbs. 4 oz., and a portion of this analyzed gave the following results:—

Insoluble matter, nearly all oxide of zinc	4.20
Oxide of zinc soluble in the soda	4.40
Water	15.00
Soda	37.00
Chloride of sodium	5.54
Nitrite of soda	5.15
Nitrate of soda	28.31
Loss	40
	<hr/>
	100.00

The 36 lbs. 4 oz. would, therefore, contain, according to this analysis (stating it in round numbers, and omitting fractions):—

23 lbs. 12 oz. of oxide of zinc and alkali, less 10 oz. water	lbs. oz.	23	2
15 lbs. 4 oz. consisting of oxide of zinc	lbs. oz.	1	5
“ soda		5	10½
“ water		2	4
“ chloride sodium		0	13
“ nitrite of soda		0	12½
“ nitrate of soda		4	5
Loss		0	2
		<hr/>	
		15	4
Less water		2	4
		<hr/>	
		13	0 = 13 0
Loss		0	2
		<hr/>	
		36	4
13 lbs. 12 oz. gaseous matter lost by the 30 nitrate of soda, consisted of 143.71 cubic feet of gas, containing—			
83.36 cubic feet of oxygen gas		7	0½
60.36 “ nitrogen gas		4	7
10 lbs. nitric acid, sp. gr. 1.136, containing 19.128 percent. dry acid, (Ure's table)		1	14½
Loss*		0	6
		<hr/>	
		50	0

With respect to the cost of the oxygen gas prepared by Webster's process, it may be stated that, taking the commercial price of nitrate of soda to be £14 10s. per ton, and the crude oxide of zinc at £2 per ton, the value of 30 lbs. of nitrate of soda would be about 3s. 10d.,

\* Probably not really a loss, but represented in the 2 lbs. of nitric acid absorbed by the solid matter in the purifier, which is, no doubt, of a higher quality than that absorbed by the 5 lbs. of water in the same purifier, and equal to 8 lbs., sp. gr. 1.136.

and that of the 20 lbs. oxide of zinc, 4d., making a total of 4s. 2d.; and the following table exhibits the probable value of the products:—

Materials— Cost of Materials.	Products.				
	Gas.	Soda.	Nitrate of Soda.	Nitric Acid.	Oxide of Zinc.
s. d. 30 lbs. Nt. Soda 3 10	143·71 cubic ft. containing	5 lbs. at 2d per lb. *	4 lbs. at 1½d. per lb. *	10 lbs. containing 2 lbs. stronger, at 6d. per lb.	20 lbs. at 4d.
20 lbs. Ox. Zinc 0 4	83·36 of oxygen.				
50 lbs. . . . 4 2	1s. 6d.	10d.	6d.	1s. 0d.	4d.

On comparing the cost of this method with those of other sources of oxygen gas, it will be noticed that Webster's is the cheapest known process, if the products can all be realized. Monsieur Deville calculates the cost of oxygen, obtained from various substances, as follows:—

One cubic metre (equal to 35·317 cubic feet):	Fr.	s.	d.
“ from chlorate of potash . . .	10 00	=	8 4
“ “ oxide of manganese . . .	4 87	=	4 0½
“ “ sulphuric acid . . .	1·00	=	0 10
“ “ nitrate of soda, ox. of zinc . . .			0 7½ 6-10
“ “ do. rejecting all products . . .	1		9 7-10

The cheapness of Webster's process is so satisfactory, that it will probably be used at the Polytechnic, provided that the nitrogen mixed with the oxygen does not materially interfere with the brilliancy of the lime-light.

*Additional Report on the above Process.* By WILLIAM CROOKES.

By the kindness of the proprietors of the patent, I have been afforded an opportunity of critically examining every stage of the above process, and am, therefore, enabled, from personal observation and experiment, to endorse all the facts given by Mr. J. H. Pepper in this report. The gas is produced from materials of but trifling value, in large quantity, and by an operation requiring no skilled superintendence whatever. At first sight it would seem that the proportion of nitrogen present with the oxygen would tend to render the gas of only slight commercial value. A little consideration will, however, show that this is not necessarily the case. Although pure oxygen is invaluable in the laboratory, and at the lecture-table, its employment in an undiluted form would be impracticable in ordinary metallurgical operations on a large scale, as the intensity of its action would very soon rise to such a degree of violence as to reduce flux, fuel, metal, and furnace into one chaotic liquid mass. It is, indeed, very doubtful whether the mixed gas which is obtained in such abundance under this patent, is not as strong as could be employed in most manufacturing operations without serious damage to the furnaces and crucibles used.

\* A chemical manufacturer would separate, by crystallization, the greater part of the nitrite, nitrates, and chloride of sodium from the caustic soda.

The only case in which it is likely a purer gas would be required, is in the metallurgy of the more refractory platinum metals. The intensity of the "lime-light" produced with this mixture is necessarily inferior to that obtained with pure oxygen, but it is abundantly sufficient for all ordinary purposes of illumination, and far better than could be anticipated from the composition of the gas. Indeed, it is only by comparing the two lights simultaneously, side by side, that the difference of intensity becomes apparent.

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*The Electric Lamp in Lighthouses.*

From the London Athenæum, Nov. 1862.

For the last five or six years the maritime world has been waiting with some anxiety for the termination of certain experiments respecting the employment of the electric light as a beacon. These experiments are well nigh concluded, and the question whether the old oil-lamp is to be superseded by the electric lamp, will be speedily determined.

Early in 1857, experiments were made on the subject at Blackwall and Woolwich by Prof. Faraday and Prof. Holmes, and subsequently the latter was requested by the Elder Brethren of the Trinity House to prepare a plan for employing the new light. This plan was submitted to Prof. Faraday, who reported favorably upon it, and the result was that the Trinity Board sanctioned the establishment of an electrical apparatus in the South Foreland Upper Lighthouse. This apparatus consisted of an accumulation of powerful magnets and iron cores with surrounding coils, accurately arranged, so that when the associated cores were revolving, they sent all their currents into one common channel, from whence they were conveyed to the lantern by conducting wires, and there produced the electric light. There was no consumption of material or energy, other than that of the burning fuel required at the steam engines to produce motion.

A trial of the light began in the lighthouse on the 8th of December, 1858; but as the apparatus was imperfect in some points, and the results unsatisfactory, the lighting by the apparatus was suspended for awhile, that the defects might be remedied. The lighting was renewed in March, 1859, and during the following month it was carefully examined by Prof. Faraday. In his subsequent Report to the Trinity Board, after describing very fully the observations he made at sea, and the various experiments by which he tested the power of the light, he states his opinion that Prof. Holmes had practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned; that the light produced was powerful beyond any other that he had seen so applied, that its regularity in the lantern was great, and its management easy. Ten months after he had thus expressed his approval of the experiment, he again visited the light, and found it of the same character as when he had last seen it. It was gene-

rally very steady, but with slight interruptions now and then from iron in the carbons. He found that it had a tendency to sudden and spontaneous extinction, arising either from the breaking off of the end of the carbon, or from some disarrangement in the fine mechanical work of the lamp. This happened three or four times every night; and being once extinguished, the lamp did not relight of itself. The slightest touch of the keeper's hand, however, was enough to restore the light; but the liability to temporary extinction occasioned an anxious watchfulness on the part of the attendant, who was constrained on this account to stay in the lantern continually. The light had never been stopped by any deficiency of action in the machine-room.

The appointed time during which the magneto-electric light was to be placed under practical trial at the South Foreland having, early in 1860, come to an end, Prof. Faraday urged the Trinity House to authorize its application, either there or somewhere else, for a further and a longer period, stating that it had proved to be practical and manageable, and had supplied the means of putting into a lighthouse lantern, for six months or more, a source of illumination far surpassing in intensity and effect any other previously employed. Acting on this suggestion, the Trinity Board established an electric light at Dungeness. At this lighthouse it is placed in an optic apparatus constructed especially for it, which is only 16 inches in height and 14 inches in external diameter. The apparatus consists of six lenticular zones, and seven reflecting zones; of the latter three are below and four above. At the South Foreland there was one electric lamp placed in the centre of a Fresnel optic apparatus. Here there are two of the new optic apparatus, placed one over the other in the axis of the lantern, and four electric lamps; for each apparatus two, only one lamp being used at a time. Mr. Holmes includes in his plan the use of all these lamps and apparatus, because of the facility of rapid change in the lamps and carbons, and they cause no alteration in the magneto-electric machines, wires, or engines, which are the same as were employed at the South Foreland.

Beside the electric apparatus, the light from which passes through the upper panes of the lantern, the original reflectors and their lamps are retained in place, so that they can be at once substituted for the electric light if any accident or failure should occur to the latter, and also may be used in conjunction *with* the electric light in a comparison of one with the other.

In one of his reports on the Dungeness light, written during the present year, Prof. Faraday mentions an interesting experiment. Arrangements were made on shore (Mr. Holmes being in charge of the light), by which observations could be taken at sea about five miles off, on the relative light of the electric lamp and the metallic reflectors with their Argand oil lamps. At the given distance the eye could not separate the two lights, but by the telescope they were distinguishable. The combined effect was a glorious light up to the five miles; then, if the electric light was extinguished, there was a great falling off in the effect; though after a few moments' rest to the eye,



it was seen that the oil lamps and reflectors were in their proper state. On the other hand, when the electric light was restored, the illumination became again perfect.

Then, whilst both were in action, the reflectors were shaded, and the electric light left alone; but the naked eye could see no sensible diminution; nor when the reflectors were returned into effectual use, could it see any sensible addition to the whole light power; though the telescope showed that the alteration in the lantern had taken place at the right time. Such was the power of the electric light that the addition or subtraction of the light of a fully effective set of reflectors, with their lamps, would not have been sensible to a mariner, however observant he might have been.

Prof. Faraday enumerates some points which are against, and others in favor of the light. In the first place, the simplicity of the present system is very great compared with that of the electric light: only two keepers are required to a lighthouse; they need possess no special knowledge; ordinary attention is all that is necessary; and thus failures of the light are almost impossible. In the new system, a second set of men will be required to attend the engines, and there must be amongst them one or more who understand the principle and construction of the lamp in the lantern, of the magneto-electric machines, the steam engines, and the condensers, and be able to make effectively the repairs necessary to the apparatus. In the next place, the expense of the new system must be large, compared with that of the present system. Other objections have been made, of which Prof. Faraday cannot see the force, namely, that the light is too bright—that it gives a false impression of the distance of the lighthouse—and that it blinds the eyes of the mariners to the perception of the lights on board vessels between it and them. These objections, he says, if they have any force, must be judged by mariners themselves.

The points in favor of the magneto-electric light are strong and clear in relation to the increase of light. In cases where the light is from lamp-flames fed with oil, no increase of light at or near the focus or foci of the apparatus is possible beyond a certain degree, because of the size of the flames; but in the electric lamp any amount of light may be accumulated at the focus and sent abroad, at of course an increased expense. In consequence of the evolution of the light in so limited a focal space, it may be directed seaward, diverging either more or less, or in a vertical or horizontal direction, at pleasure, with the utmost facility. The enormous shadow under the light produced by the oil-flame burner, which absorbs and renders useless the descending rays to a very large extent, does not occur in the magneto-electric lamp; all the light proceeding in that direction is turned to account; and the optical part of the arrangement, whether dioptric or reflecting, might be very small in comparison with those in ordinary use.

With reference to the final experiment now taking place at Dungeness, though Prof. Faraday thinks that many changes might be made in the size, arrangement, and adjustment of the optic apparatus, he reserves these points for longer and future consideration, aided by the instruction that will arise from the results of experience.

*Use of the Balloon for Scientific Purposes.*

From the London Athenæum, Sept., 1862.

In Mr. Glaisher's hands the balloon is restored to its old rank of a philosophical agent. Gay-Lussac has only shown the men of science how to use the balloon for scientific purposes; and considering how much has been done in the way of scaling peaks for the same science, it is surprising that the balloon has not been more largely used. But Mr. Glaisher, by his successive ascents, is adding largely to our knowledge of the higher regions of the atmosphere. Speaking of his own personal feelings in his last ascent, he says—"When we attained the height of two miles, at 1 h. 21 m., the temperature had fallen to the freezing point; we were three miles high at 1 h. 28 m., with a temperature of  $18^{\circ}$ ; at 1 h. 39 m. we had reached four miles, and the temperature was  $8^{\circ}$ ; in ten minutes more we had reached the fifth mile, and the temperature of the air had passed below zero, and there read minus  $2^{\circ}$ ; at this point no dew was observed on Regnault's hygrometer when cooled down to minus  $30^{\circ}$ . Up to this time I had taken the observations with comfort. I had experienced no difficulty in breathing, while Mr. Coxwell, in consequence of the necessary exertion he had to make, had breathed with difficulty for some time. At 1 h. 51 m. the barometer read 11.05 inches, but which requires a subtractive correction of 0.25 inch, as found by comparison with Lord Wrottesley's standard barometer just before starting, both by his Lordship and myself, which would reduce it to 10.8 inches, or at a height of about  $5\frac{1}{4}$  miles. I read the dry bulb as minus  $5^{\circ}$ ; in endeavoring to read the wet bulb I could not see the column of mercury. I rubbed my eyes, then took a lens, and also failed. I then tried to read the other instruments, and found I could not do so, nor could I see the hands of the watch. I asked Mr. Coxwell to help me, and he said he must go into the ring, and he would when he came down. I endeavored to reach some brandy, which was lying on the table at about the distance of a foot from my hand, and found myself unable to do so. My sight became more dim; I looked at the barometer and saw it between 10 and 11 inches, and tried to record it, but I was unable to write. I then saw it at 10 inches, still decreasing fast, and just noted it in my book; its true reading, therefore, was at this time about  $9\frac{3}{4}$  inches, implying a height of about  $5\frac{3}{4}$  miles, as a change of an inch in the reading of the barometer at this elevation takes place on a change of height of about 2500 feet. I felt I was losing all power, and endeavored to rouse myself by struggling and shaking. I attempted to speak, and found I had lost the power. I attempted to look at the barometer again; my head fell on one side. I struggled, and got it right, and it fell on the other, and finally fell backwards. My arm, which had been resting on the table, fell down by my side. I saw Mr. Coxwell dimly in the ring. It became more misty, and finally dark, and I sank unconsciously as in sleep; this must have been about 1 h. 54 m. I then heard Mr. Coxwell say, 'What is the temperature? Take an observation; now try.' But I could neither see, move, nor speak. I then heard him speak more

emphatically, 'Take an observation; now do try.' I shortly afterwards opened my eyes, saw the instruments and Mr. Coxwell very dimly, and soon saw clearly, and said to Mr. Coxwell, 'I have been insensible;' and he, replied, 'You have, and I nearly.' I recovered quickly, and Mr. Coxwell said, 'I have lost the use of my hands; give me some brandy to bathe them.' His hands were nearly black. I saw the temperature was still below zero, and the barometer reading 11 inches, but increasing quickly. I resumed my observations at 2 h. 7 m., recording the barometer reading 11.53 inches, and the temperature minus 2°. I then found that the water in the vessel supplying the wet bulb thermometer, which I had by frequent disturbances kept from freezing, was one solid mass of ice. Mr. Coxwell then told me that while in the ring he felt it piercingly cold, that hoar frost was all round the neck of the balloon, and on attempting to leave the ring he found his hands frozen, and he got down how he could; that he found me motionless, with a quiet and placid expression on the countenance. He spoke to me without eliciting a reply, and found I was insensible. He then said he felt insensibility was coming over himself; that he became anxious to open the valve; that his hands failed him; and that he seized the line between his teeth, and pulled the valve open until the balloon took a turn downwards. This act is quite characteristic of Mr. Coxwell. I have never yet seen him without a ready means of meeting every difficulty as it has arisen with a cool self-possession that has always left my mind perfectly easy, and given to me every confidence in his judgment in the management of so large a balloon. On asking Mr. Coxwell whether he had noticed the temperature, he said he could not, as the faces of the instruments were all towards me; but that he had noticed that the centre of the aneroid barometer, its blue hand, and a rope attached to the car were in the same straight line. If so, the reading must have been between 7 and 8 inches. A height of six miles and a half corresponds to 8 inches. A delicate self-registering *minimum* thermometer reads minus 12°; but unfortunately I did not read it until I was out of the car, and I cannot say that its index was not disturbed. On descending, when the temperature rose to 17° it was remarked as warm, and at 24° it was noted as very warm. The temperature then gradually increased to 57½° on reaching the earth. It was remarked that the sand was quite warm to the hand, and steam issued from it when it was discharged. Six pigeons were taken up. One was thrown out at the height of three miles; it extended its wings and dropped as a piece of paper. A second, at four miles, flew vigorously round and round, apparently taking a great dip each time. A third was thrown out between four and five miles, and it fell downwards. A fourth was thrown at four miles when we were descending; it flew in a circle, and shortly after alighted on top of the balloon. The two remaining pigeons were brought down to the ground; one was found to be dead, and the other (a carrier) had attached to its neck a note. It would not, however, leave, and when jerked off the finger returned to the hand. After a quarter of an hour it began to peck at

a piece of riband encircling its neck, and I then jerked it off my finger, and it flew round two or three times with vigor, and finally towards Wolverhampton. Not one, however, had returned there when I left on the afternoon of the 6th. It would seem from this ascent that five miles from the earth is very nearly the limit of human existence. It is possible, as the effect of each high ascent upon myself has been different, that on another occasion I might be able to go higher, and it is possible that some persons may be able to exist with less air and bear a greater degree of cold; but still I think that prudence would say to all, whenever the barometer reading falls as low as 11 inches, open the valve at once; the increased information to be obtained is not commensurate with the increased risk."

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### *British Weights and Measures.*

From the London Chemical News, No. 150.

Omitting many specific anomalies, we have no less than ten different systems of weights and measures, most of them established by law:—1. Grain, computed decimally, used for scientific purposes; 2. Troy weight, under 5 Geo. 4, c. 74, and 18 & 19 Vict., c. 72; 3. Troy ounce, with decimal multiples and divisions, called bullion weights, under 16 & 17 Vict., c. 29; 4. Bankers' weights, to weigh 10, 20, 30, 50, 100, and 200 sovereigns; 5. Apothecaries' weight; 6. Diamond weights and pearl weights, including carats; 7. Avoirdupois weight, under 5 Geo. 4, c. 74, and 18 & 19 Vict., c. 72; 8. Weights for hay and straw; 9. Wool weight, using as factors 2, 3, 7, 13, and their multiples; 10. Coal weights, decimal, under 1 & 2 Will. 4, c. 76, and 8 & 9 Vict., c. 101, Nos. 1, .3, .2, .1, .05, .025. We have also, in occasional scientific use, the weights of the metric system. For measures of length, we have the ordinary inch, foot, and yard. We have, in cloth measure, yards, nails, and ells. There are four different sorts of ells. For nautical purposes, we have fathoms, knots, leagues, and geographical miles differing from the common mile. The fathom of a man-of-war is 6 feet; of a merchant vessel,  $5\frac{1}{2}$  feet; of a fishing-smack, 5 feet. We have also the Scotch and Irish mile, and the Scotch and Irish acre. There are several sorts of acres in the United Kingdom, and there are a great variety of roods. We have, in almost every trade, measures of length especially used in those trades: for the measurement of horses we have the hand; shoemakers use sizes; and we are compelled to adopt gauges where the French use the *millimètre*. These gauges are entirely arbitrary. The custom of the trade is the only thing which would decide the question in case of dispute. For measures of capacity we have twenty different bushels; we can scarcely tell what the hogshead means: for ale, it is 54 gallons; for wine, 63. Pipes of wine vary in many ways; each sort of wine seems to claim the privilege of a different sort of pipe. For measures of weight we have about ten different stones: a stone of wool at Darlington is 18 lbs.; a stone of flax at Downpatrick is 24 lbs.; a stone of flax at Belfast is only  $16\frac{3}{4}$  lbs.; but it is also at Belfast  $24\frac{1}{2}$  lbs., having in

one place two values. The hundredweight may mean 100 lbs., 112 lbs., or 120 lbs. If you buy an ounce or pound of any thing, you must inquire if it belongs to Dutch, troy, or avoirdupois weight.—*Report of the Select Committee.*

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*Rapid Growth of Vegetables in High Latitudes.*

From the Intellectual Observer, August, 1862.

In a valuable treatise on the vegetable productions of Norway, which has been published by Dr. Mueller, in connexion with the Norwegian department of the Exhibition, some extraordinary facts are related respecting the influence of the long duration of light, during the summer months, on the growth of vegetables in the higher latitudes in Norway. At seventy degrees N. it was found that ordinary peas grew at the rate of three and a half English inches in twenty-four hours for many days in summer, and that some of the cereals also grew as much as two and a half inches in the same time. Not only is the rapidity of growth affected by the constant presence of light, but those vegetable secretions which owe their existence to the influence of actinic force on the leaves, are also produced in far greater quantity than in more southern climates; hence the coloring matter and pigment cells are found in much greater quantity, and the tint of the colored parts of vegetables is consequently deeper. The same remark applies to the flavoring and odoriferous matters, so that the fruits of the north of Norway, though not equal in saccharine properties, are far more intense in flavor than those of the south.

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*Artificial Tourmalines.* By JAMES W. YOUNG.

From the London Chemical News, No. 147.

SIR—In reply to your correspondent's inquiry relative to a method of forming "Herepath's Artificial Tourmaline," I beg to inform him that he will find the requisite information in the following extract from Bird and Brookes' Natural Philosophy, page 503:

"Dissolve 50 grains of disulphate of quinine in two fluid ounces of acetic acid, and two of proof spirit warmed to 130° F., in a very wide-mouthed flask or glass beaker; then slowly add 50 drops of a mixture of 40 grains of iodine in an ounce of rectified spirit; agitate the mixture, and then set it carefully aside for six hours, in an apartment maintained at a temperature of about 50° F. The utmost care must be taken to avoid any motion of the vessel; indeed, all accidental vibrations should be guarded against by suspending the vessel by a string, or by allowing it to rest on a mass of cotton wool. If, in six hours, the *large* laminæ of the salt have not formed, warm the fluid with a spirit-lamp, and when it has become clear, add a few drops of the solution of iodine in spirit. The large laminæ form on the top of the fluid, and should be removed carefully by gliding under one of them a circular piece of thin glass. The specimen should be drained by resting the edge of the glass on a piece of bibulous paper, but it must not

be touched, on account of its extreme fragility; if any small crystals adhere to its surface, they must be washed off by pouring over it a few drops of watery solution of iodine. When dry, the specimen should be placed for a few minutes under a bell-glass by the side of a watch-glass containing a few drops of tincture of iodine; and, lastly, a little very fluid Canada balsam should be dropped on it, and a thin glass cover applied without heat. Specimens may thus be obtained of extreme thinness, and half an inch in diameter or even larger, possessing scarcely the slightest color, and yet completely polarizing transmitted light.

Glasgow.

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### *A New Vehicle for Paints.*

M. Oudry, of Auteuil, has found that benzine and coal-oil are the best vehicles for paints of metallic basis (lead, zinc, &c.) as they dry rapidly, have no smell after the first twenty-four hours, and present a very fine grain. He has also made a very superior bronze by pulverizing copper deposited galvanically.—*Cosmos*.

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### *Disintegrated Black Lead.*

From the London Intellectual Observer, August, 1862.

The chemically-disintegrated graphite of Mr. Brodie is a subject of great interest, as it affords a ready means of obtaining a chemically pure black lead, that by mechanical pressure can be aggregated into a solid mass, and employed for those purposes for which the best and most expensive plumbago has hitherto alone been applicable. The outline of the process may be thus stated; the impure plumbago is mingled with chlorate of potash, and then acted upon by a mixture of nitric and sulphuric acids; these not only give rise to the evolution of gaseous chlorine compounds, but also dissolve up and remove many of the impurities. The plumbago, thus obtained in a pure form, is washed and heated, the result of the combined mechanical and chemical action of these operations is, that the plumbago is so perfectly disintegrated as to be formed into light floculi, which are capable of being blown away by the slightest current of air. In this condition they are readily condensed into solid blocks by pressure.

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### *Application of the Spectroscope in the Arts.*

The French metallurgists have found an ingenious and no doubt valuable application of the new discoveries as to the differences in the light from different substances when burning. In the new process for making steel, there is a certain point in the operation at which the cover of the furnace should be lowered. A certain time is required for the escape of the gases which would injure the qualities of the steel, but after they have all escaped, should the furnace throat be left open, the action would be in another way not less injurious to

the steel. It is now proposed to determine the proper moment by observation of the flame by the spectroscope, and so soon as the flame shows the absence of the gases to be expelled, the cover is lowered upon the furnace.

*Cosmos.*

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*New Explosive Compound.*

From the London Artizan, Oct., 1862.

A new explosive powder, invented by Mr. Reynaud de Tret, appears destined to render great services to the working of mines in consequence of its low cost price. It is stated to be particularly applicable to the working of stone quarries. It is composed as follows:—Nitrate of soda, 52·5; residue of tan (after having been used in the tanning of hides), 27·5; pounded sulphur, 20·0; total, 100·0.

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*An Exhibition of Native Produce and Industry in Turkey.*

From the London Builder, No. 1030.

The example of the International Exhibition seems not to have been lost on the Porte. A grand show of native produce and industry has been decided on, and will be held in Stamboul during the coming Ramazan. To secure the successful realization of this idea, special local delegates are to be at once appointed in all the principal districts of the empire, for the collection and classification of samples. These last will be forwarded to the capital free of all custom or other dues, and at the Government expense. As in London, sales of the articles exhibited will be allowed; and, in the event of their not being so disposed of, the Government will engage to buy all the smaller parcels. Prizes, in money or medals, will also be given to the successful exhibitors.—*Levant Herald.*

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PROCEEDINGS OF THE BRITISH ASSOCIATION.

From the London Athenæum, Oct. 1862.

*Section G.—Mechanical Science.*

The President, Dr. W. Fairbairn, opened the proceedings with an address in which, after briefly alluding to the great advance made in the application of science to the useful arts during the last fifty years, he proceeded to advert to the progress and position of mechanical science as shown in the International Exhibition. A very casual glance at this exhibition, as compared with those of 1851 and 1855, shows with what energy the public mind has been at work; and though there is no new discovery of importance in mechanical science, yet the machines are more compact and better executed than at any previous exhibition, and a great deal is to be seen of a character both interesting and instructive. In land steam engines, the horizontal is rapidly supplanting the beam or vertical engine, and is applied not only with efficiency to manufacturing but also to agricultural purposes. In marine engines we are without rivals: we find in them beauty of execution, compact form and colossal dimensions, combined with a simplicity,

concentration of power, and precision of action never before equalled in this or any other country; and it must be a source of pride that this country, the first maritime nation in the world, should stand pre-eminently first as the leader of naval propulsion. In locomotives, if we are not in advance of other countries, we are not behind them; though both France and Germany exhibit splendid specimens of engines. There is, however, in this country a greater simplicity of construction, greater compactness of form, and clearer conceptions in working out the details. With regard to machines, and tools, the creators of machines, at no period before has such an exhibition been seen. Some of the tools, such as the turning, planing, boring and slotting machines, are of a very high order; and the tool machines for the manufacture of fire-arms, shells, rockets, &c., are of such a character as to render all the operations, however minute, perfectly automatic, with an accuracy of repetition that leaves the finished articles identical with every other article from the same machine. Such, indeed, is the perfection of the tool system, that in almost every case we may calculate on no deviation beyond the one-thousandth of an inch.—The speaker then proceeded to notice the spool machine for winding sewing thread on bobbins, the paper-bag making machine, and the riband saw machine. He then adverted to the changes in the construction of ordnance, and in the art of defence. For a time it was considered that ships plated with iron  $4\frac{1}{2}$  inches thick were invulnerable to shot or shell; and this opinion was acted upon in this country, in France, and in America. Our Government experiments have to a great extent dispelled these notions. It has been proved that a smooth bored Armstrong gun with a 150-lb. spherical shot can pierce a  $4\frac{1}{2}$  inch plate and 18 inches of teak. In fact it has been proved by experiments that no vessel yet constructed is able to carry armor-plates of sufficient thickness to resist such powerful ordnance as has been brought against it. The best description of iron has been sought for and obtained, and the balance of power had, however, remained in favor of the gun,—but with this qualification, that the gun had to sustain an explosive force of powder equivalent to one-third the weight of the shot—a charge which the gun was unable to bear. Under ordinary circumstances, with the usual charge of one-eighth the weight of the shot, it might be reasonably inferred that the balance of strength was on the side of the plate, and the guns of such heavy calibre were insufficient in strength to sustain these enormous charges of powder. The results, too, had only been produced by these heavy charges at short distances. It was determined to try the effect of the Horsfall gun, 22 tons weight, with a charge of 75 lbs. of powder and a 300-lb. shot, against the Warrior target of  $4\frac{1}{2}$  iron and 18 inches teak: the result was, the penetration of the mass with a huge opening into the target of upwards of 2 feet in diameter. This experiment would not apply to ships of war which could not carry ordnance of such immense weight, but was applicable to the case of forts, from which an enemy's ship might be struck at the distance of 1000 yards.—Passing from the Horsfall gun, Mr. Fairbairn related the late experiments with the



Whitworth gun. There had been very early established the distinction between the penetrating powers of solid shot and shell, the shell invariably failing to penetrate even a moderately thick plate of iron, and it was concluded that a comparatively thin plate was a sufficient defence against it:  $2\frac{1}{2}$  inches, and even 2 inches, were considered a sufficient thickness. The late experiments with a Whitworth gun and flat-fronted hardened shells had, however, dispelled these notions. The 12-pounder at 200 yards sent these shells through a 2 inch plate backed with a foot of timber. It had been suggested that a more powerful armor might be constructed by dividing the armor into two plates, each half of two inches thickness, and these plates separated by a certain space; the theory being that, though the first might be pierced, yet the force of the shell would be so deadened that the second plate would stop it. The Whitworth 70-pounder was tried against a target on this principle. A strong oak frame, armed with a 4-inch plate, was attached to a second plate of 2 inches thick, an interval of two or three feet being left between them. The shell with only 12 lbs. of powder pierced the outer side of the target completely, oak and iron together, after which it burst inside the frame and shattered it to pieces. From this it was clear that 4 inches of solid iron and 9 inches of wood was no protection against such a gun, and that no gun-boat, such as those on American waters, was proof against such a weapon. In point of fact, Mr. Whitworth, with a rifled gun lighter than a 68-pounder, could destroy them with his steel-hardened shells at a distance of 1500 or 2000 yards. A further experiment with a larger Whitworth gun, a 120-pounder, at a distance of 600 yards, proved that the sides of the *Warrior* are no longer shell-proof. A 130-lb. solid shot, with a charge of 23 lbs. of powder, went through the  $4\frac{1}{2}$ -inch plate, and lodged in the wood behind it. A shell of the same weight, with a charge of 25 lbs. of powder, penetrated the armor plate and exploded, tearing the wood backing, and lodging in the opposite side. From these experiments, Mr. Fairbairn inferred that the victory is on the side of the gun, and that it may be difficult, under such powerful odds, to construct ships of sufficient power to prevent their destruction by the entrance of shells.

Mr. J. Nasmyth then described his "Improved Form of Link Motion."—There were many contrivances for effecting the same purpose as the "link" motion; but the latter, the invention of a mechanic in the employ of the Stephensons, had superseded all others. Mr. Nasmyth showed how, by his modification of it, a greater simplicity of construction was obtained, and a greater freedom from the evils which the wear and tear of the ordinary link motion produced. He had invented it in 1852, but it was little known. It had, however, been adopted with great success by Mr. Humphreys. It would be seen on the engine exhibited by that gentleman in the International Exhibition.

Mr. E. E. Allen read a paper "On the Importance of Economizing Fuel in Iron Plated Ships,"—pointing out that a great saving might be effected in the consumption of coals, by using a longer stroke engine.

Mr. Scott Russell said it was agreed that the short-stroke engine was wasteful of steam and fuel.

Dr. F. Grimaldi read a paper descriptive of a New Marine Boiler for generating Steam of High Pressure. His boiler was a cylindrical tubular boiler, with certain arrangements of radial tubes for taking up and conveying the steam, and made to rotate slowly in the furnace on its axis. The advantages claimed were, freedom from priming, smallness of space occupied, superheating the steam, and economy of fuel.

A discussion ensued, in which the President, Messrs. Appold, Scott Russell, Siemens, E. E. Allen, and Beardmore took part; the general tone of the discussion being favorable to the invention.

Mr. W. Thorold then read a paper "On the Failure of the Sluice in Fens, and on the Means of Securing such Sluices against a Similar Contingency."—The author described the circumstances attending the failure of the sluice, and pointed out that, in his opinion, the mode of preventing such an accident in future was the employment of double sluices, one behind the other, the water between the two being always kept locked in at a mean height between the water in the drain and that on the sea-side.

The discussion was adjourned till Monday, in order that the members should have an opportunity of previously seeing the place, to which an excursion would be made on Saturday.

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Mr. J. Oldham read the Report of the Committee appointed last year to make "Tidal Observations in the Humber." The observations were made at three places: New Holland, Hull Victoria Docks, and at Goole Docks. They were taken every five minutes at New Holland and at Goole, and every fifteen minutes at Hull Docks. The observations comprised 55 tides, and were taken at a period when little or no wind occurred to disturb the ordinary rise and fall. The results were carefully tabulated and presented to the Section. These observations fully bore out the statement made by Mr. Oldham at the Manchester Meeting of the Association, that at Hull, for three hours after the tide has attained to the 16-foot mark there is no more rise.

"On the Strains in the Interior of Beams and Tubular Bridges," by the Astronomer Royal.—The Astronomer Royal, after briefly advertising to the circumstance that he now addressed the Section in the same place in which more than thirty years previously he was accustomed (as Plumian Professor) to deliver lectures, sometimes on subjects analogous to this now before them, proceeded with the subject nearly in the following order. He had often desired to know (as probably many members of the Section had desired) what were the directions and magnitudes of the crumpling or stretching actions in the sides of our great tubular bridges, and had referred to several books on related subjects, but derived no assistance from them. After several attempts, he had at length succeeded in constructing a satisfactory theory. It was first necessary to acquire an idea of the measure of compressing or tensile forces in planes (the whole investigation as regarded bridges,

being confined to their vertical planes), and this would be the length of the ribbon of metal whose weight acting on any limited space would produce the compression or tension sustained by that limited space. Next, it was necessary to find according to what law the effect of the force varies when its direction varies (as, for instance, what is the tendency to tear open a fissure, if the direction of a tensile force rotates in the plane of the metal); and he found it proportional to the square of cosine of the angle which the direction of the force makes with the normal to the line sustaining the action. Using this fundamental theorem, he was able to show that the most complicated combination of forces might be reduced to the combination of two forces at right angles to each other; both forces being compressive, or both tensile, or one compressive and the other tensile. The problem, therefore, in any given case of a beam, would be, to find the magnitudes of two forces and the direction of one (three elements in all) at every point of the beam. Conceive, then, a beam to be divided (optically, not mechanically) into two parts, by a curved line in its vertical plane, extending from the lower to the upper edge, and consider the equilibrium of the more advanced part of the beam. The forces which act on it are,—the compressing or tensile forces acting over the imaginary curved line, the weight of the different portions of the more advanced part of the beam, and the reaction of supports in that part of the beam. It is soon found that the symbols for the three elements above mentioned become combined in forms which render it convenient to use three new symbols for their combinations, including also the weight of the advanced part of the beam. Putting  $L$ ,  $M$ ,  $o$ , for these symbols,  $R$  for a vertical reaction at the distance  $h$  in the direction of  $x$  ( $x$  horizontal), the three equations of equilibrium are)—

$$(\text{Equation for forces in } x), \int dx. (L_x + M) = o;$$

$$(\text{Equation for forces in } y), \int dx. (M_y + o) - R = o;$$

$$(\text{Equation of momenta}), \int dx. \left\{ y (L_y + M) + x (M_y + o) \right\} - R h =$$

$$o: p \text{ being put for } \frac{dy}{dx}.$$

The equations in this form are somewhat unmanageable; but the following fortunate idea removed all difficulty:—Since the equations are true for any curve, and are, therefore, true (*mutatis mutandis*) for any curve near another, the difference in the equations produced by stepping from one curve to another will be  $= o$ . This is evidently a case for application of the process of the Calculus of Variations.

On applying it, the first equation gives  $\frac{dM}{dy} - \frac{dL}{dx} = o$ ; the second gives

$$\frac{do}{dy} - \frac{dM}{dx} = o: \text{ the third gives an equation, then, identically true.}$$

From this it follows, immediately, that the three quantities,  $L$ ,  $M$ ,  $o$ ,

may thus be represented, in terms of one function,  $F$  of  $x$  and  $y$ , and of arbitrary functions,  $\phi$  and  $\psi$ ;  $L = \frac{d^2 F}{dy^2} + \phi(y)$ ,  $M = \frac{d^2 F}{dxdy}$ ,  $O = \frac{d^2 F}{dx^2}$

$+ \psi(x)$ . Now suppose  $F$  is so chosen that the equations may be satisfied without  $\phi(y)$  and  $\psi(x)$ ; then it is evident that  $\phi(y)$  and  $\psi(x)$ ; will satisfy the equations without their last constant terms: they may, therefore, be multiplied or aggregated in any degree; and upon viewing the way in which they enter into the equations, they are simple forces—one in the direction of  $x$ , and the other in the direction of  $y$ . It is plain therefore, that these are accidental forces in the interior of the metal, such as are produced by injudicious casting of fusible metal, or injudicious union of malleable metal; they are not subjects for present contemplation and are to be omitted. Omitting them, and substituting the simpler expressions for  $L$ ,  $M$ ,  $O$ , in the equations, every part becomes integrable *per se*; and the integrated equations become the following (in which the values for the first part of the curve, where  $x = z$ ,  $y = 0$ , are to be subtracted from those for the extremity of the curve at the upper corner of

the end of the beam, where  $x = 2r$ ,  $y = s$ ):  $\frac{dF}{dy} = 0$ ,  $\frac{dF}{dx} = R$ ,  $y \frac{dF}{dy} + x \frac{dF}{dx} - F = Rhs$ : equations of remarkable simplicity. Various consid-

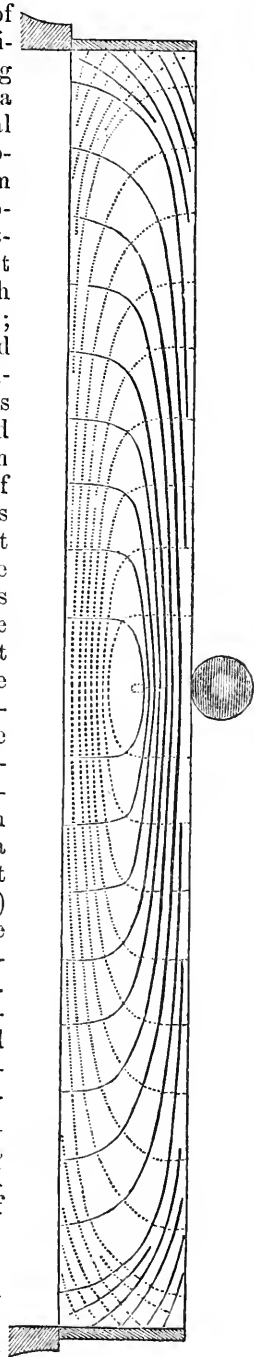
erations show that the expressions for the forces will contain only integral powers of  $x$  and  $y$ . Assuming, then, a form for  $F$ , with indeterminate co-efficients, several relations are given by these equations. Still, it is necessary to find other considerations, in each special case, which will produce due limitation of the extreme generality of form. For this purpose reference is made to the theorems of ordinary mechanics, by which, in the case of a strained elastic beam, the horizontal disruptive force is found. This force is the equivalent of  $-L$  or  $-\frac{d^2 F}{dy^2}$ .

This consideration in every case is sufficient; it being always

necessary to ascertain that the three equations are satisfied.  $F$  being thus completely determined, and  $L$ ,  $M$ ,  $O$ , being found, the original three elements (two forces and the direction of one) are obtained numerically without difficulty. As a specimen of the forms assumed by  $F$ ; in the instance of a beam whose length is  $2r$  and depth  $s$ , supported on two piers,  $F = \frac{1}{2s^2} (x^2 - 2rx) (3sy^2 - 2y^3)$ . It was pointed

out that the state of the end of the beam in this instance required special consideration. In other vertical sections of the beam, a strain on one side is met by a nearly equal strain on the other side of the section; but at the end, though the forces are considerable, there is no antagonistic force. On resolving the forces it is found that the horizontal force  $= 0$ ; but the vertical force is considerable, being aggregated by successive vertical pressures from the top to the bottom, where this

sum at last amounts to half the weight of the beam. This gives rise to the necessity, recognised by engineers, of inserting a strong vertical frame in the end of a tubular bridge. The Astronomer Royal then stated that he had applied the theory to the following cases:—1. A beam projecting from a wall; 2. A beam supported at both ends; 3. A beam supported at both ends, and carrying a weight on its centre; 4. A beam supported at both ends, and carrying an eccentric weight; together with two others to be mentioned shortly. Of the instance No. 3, he exhibited a large drawing, in which the strains and their directions have been computed for 231 points; and he called attention to the following special distributions of force:—The great longitudinal strains near the centre of the beam's length, but not in the centre of its depth; and the considerable inclined strains near its ends, of which there is little trace in the middle; as also to the circumstance that at the middle of the beam's depth the forces make angles of  $45^\circ$  with the horizon, throughout; and sensibly the same angles at the end of the beam. The Astronomer Royal then referred to the remarkable contrivance adopted in the junction of the tubular segments of the Britannia Bridge, in which (by raising the distant end of one segment at the time of union) the junction was so effected as to strain the middle of each segment upwards, thereby doubling the strength of the bridge. He pointed out that this contrivance introduces an additional term in the third equation, expressing the addition of a *moment*. He had applied the theory completely to the two cases: 5, where such strains are impressed on both ends of a tube; 6, where such a strain is impressed on only one end of a tube. The lines of strain are very much changed. In No. 5, the inclined strains, which in Nos. 2 and 3 are at the ends, are now advanced towards the middle; and the ends, as well as the middle, are principally affected



[Strains in the interior of a beam or tubular bridge, whose ends rest upon piers, and which supports, at the middle of its length, a weight equal to half the weight of the beam. The continuous curves indicate the direction of thrust or compression, and the interrupted curve or chain lines indicate the direction of pull or tension.]

by longitudinal strains. It was then pointed out that all these conclusions depend on an assumed physical principle, of which Mr. W. H. Barlow's experiments appear to suggest a slight modification. The Astronomer Royal concluded by addressing himself to Members of the University present with the remark, that in problems like this, applying to constructive mechanics, as well as in those applying to the system of the world, examples might be found illustrating the beauty and the power of mathematics, at least equal to those suggested by the ingenuity of examiners, and possessing that dignity which attaches to reality of application.

This communication gave rise to several comments.—Dr. Robinson stated that he had himself desired to investigate the subject mathematically, and had arrived at equations probably identical with those first found here, but had been unable to reduce them to a manageable form.—Professor Rankin had made some advance in the theory, and in particular had ascertained the law of aggregation of pressure in the end frames, which the Astronomer Royal recognised as agreeing with his own. Professor Rankin considered that a great step had been gained in the present communication, in showing that all the pressures might be made to depend on one function,  $F$ .—Mr. Fairbairn gave an interesting account of the way in which experiments had been carried on in reference to the then future construction of the Britannia Bridge, the models being loaded till they broke down in different ways, and being then strengthened in those parts and again tried. He recognised the conclusions of the theory as agreeing precisely with the results of the experiment.—Mr. Scott Russell also described the views which had guided him in planning the various parts of tubular bridges, which led to an according result.—On the suggestion of some Members of the Section, that the lines of strain bear some relation to the lines of polarization and dipolarization produced by strained glass, the Master of Trinity remarked that this view had been suggested many years ago by Sir David Brewster, and that it had been partly illustrated by experiments made in this very lecture-room.

Professor D. T. Ansted, M. A., read a paper "On Artificial Stones." In this paper the author described the various materials and contrivances used for the purpose of replacing stone where natural stone could not be advantageously procured. He described, in succession, terra cottas, cements, and siliceous stones, pointing out the character, properties, uses, advantages and disadvantages of each. He alluded to experiments made in the laboratory on the various methods suggested for preserving stone by a Section of the Committee recently appointed by the Board of Works in reference to the Palace of Westminster; Dr. Hoffman, Dr. Frankland, Mr. Abel and the author being members of it. During their investigations a remarkable material was submitted by Mr. Ransome for their consideration, and its discovery arose out of Ransome's method of preserving stone by effecting a deposit of silicate of lime within the substances of the absorbent stone, by saturating the surface with a solution of silicate of soda, and then applying a solution of chloride of calcium; thus producing a rapid

double decomposition, leaving an insoluble silicate of lime within the stone, and a soluble chloride of sodium, which could afterwards be removed by washing. To prove this, Mr. Ransome made small blocks of sand in moulds by means of silicate of soda, and then dipped them in chloride of calcium. The result was the formation, almost instantaneously, of a perfectly compact, hard, and to all appearance, a perfectly durable solid. Mr. Ransome at once adopted the process for the formation of an artificial stone which, the author of the paper considered, would combine the advantages and show some of the disadvantages of other artificial stones. Experience, however, can alone be the test of its durability. A specimen weighing two tons is shown in the International Exhibition, and the substance is used in the stations of the Metropolitan Railway. It is cheap, can be made on the spot of almost any rubbish or material, and of any form or size. Experiments made by Mr. Ransome show that, as compared with Portland stone or Caen stone, a bar with section 4 inches square and 8 inches long, between supports, sustained 2122 lbs. suspended midway between the supports, while similar bars of Portland and Caen stone broke respectively with 750 lbs. and 780 lbs. The adhesion of the stone is shown by weights suspended from a piece prepared to expose a sectional area of  $5\frac{1}{2}$  inches. Caen stone separated at 768 lbs.; Bath, at 796 lbs.; Portland, at 1104 lbs.; Elland Edge, at 1874 lbs.; Ransome's, at 1980 lbs. A cube of 4 inches sustained 30 tons. Mr. Ransome showed the process to the Section by making several pieces in the presence of the Members and the process was also exhibited afterwards at the *Soirée* in the Guildhall.

Mr. R. W. Woolcombe then brought forward a paper "On Oblate Projectiles with Cycloidal Rotation contrasted with Cylindro-ogival Projectiles having Helical or Rifle Rotation."—The object of this paper was further to discuss the views of the author given in a paper read before the Royal Society in March last, entitled "An account of some Experiments with Eccentric Oblate Bodies and Disks as Projectiles," and to show the results of further experiments. Rifled cannon, it appears, cannot project heavy elongated shot with high initial velocity; and, except with the Whitworth flat-headed shot, the penetration of iron plates can only be effected by means of a high velocity. The author considers that, however well the helical or rifle method with cylindrical elongated shot may answer for small arms, yet that, when we wish to project great weights with great and sustained velocities, we shall succeed better if our mechanical arrangements were less antagonistic than the rifle principle to the great laws of nature as exhibited in the form, method of rotation and translation of the great natural projectiles, the planets. None of these are prolate bodies projected with helical rotation about their longest diameters and in the direction of their axes. The author states that he has found it practicable to project a body that, instead of being prolate, is more or less oblate; that, instead of having helical rotation at the *expense* of translation, has cylindrical rotation in *aid* of translation.

A projectile having a circular periphery in the line of motion in the gun leaves the bore as freely as a common round shot, and has the additional security for high initial velocity of windage less than for round shot of similar weight. The terminal velocity is also provided for by the oblateness, and by the axis of rotation being always transverse to and not in the plane of the trajectory. The gun has a similar transverse section to that of the projectile, the bore being straight and smooth. The projectile is a disk, and it should be *slightly* eccentric to make it rotate—so slight as to be little more than the inevitable eccentricity of every spherical projectile. The author then gave the results of some actual experiments with a gun and projectiles made on this principle. The gun was  $20\frac{1}{4}$  inches long; the calibre long diameter  $1\frac{7}{8}$  inch, and short diameter  $\frac{3}{4}$  inch. The shot weighed nearly 8 ounces, with a charge of  $2\frac{1}{4}$  ounces, or  $\frac{3}{5}$  the weight of the shot; the penetration at 25 yards from an oak target was a mean of 11 inches, reckoning to the near side of the disk, and to the far side nearly 13 inches. The initial velocity measured by Haver's Electro-ballistic Apparatus, was 1487 feet per second. A comparison was made with a small brass gun, length of bore 34.625 inches, or nearly double the length of the author's gun in calibres. The mean calibre of the brass gun was 1.6 inch, the mean diameter of the round shot was 1.43 inch; and this gun, fired with a proportionate charge of powder, showed that the disk gun gave more than double the penetration of the brass gun, and an initial velocity of 1487 to 1091 of the latter. He thought that these remarkable experiments showed that the subject was worthy of further consideration.

Mr. Le Neve Foster read a paper communicated by Mr. C. Hart, "On Type Composing and Distributing Machines," in which the author described and pointed out the advantages of Mitchel's Machine, shown in the western annexe of the International Exhibition, and which was stated to be in successful operation in several printing establishments in this country and in the United States of America. The details are too complicated to be briefly described or made intelligible without the aid of diagrams.

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## FRANKLIN INSTITUTE.

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*Proceedings of the Stated Monthly Meeting, Jan. 15, 1863.*

John Agnew, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Geographical Society and the Society of Arts, London; the Literary and Philosophical Society, Liverpool; and the Cornwall Polytechnic Society, Falmouth, England; the Oesterreichischen Ingenieur-Vereines, and the K. K. Geologischen Reichsanstalt, Vienna, Austria; the Hon. Secretary of the U. S. Treasury; the U. S. Naval Observatory, and F.



Emmerick, Esq., Washington, D. C.; and from John May, Esq., Prof. John F. Frazer, and Orrin Blodgett, Esq., Philadelphia.

Donations to the Cabinet of Minerals from J. Jenkinson, Esq., Bethlehem, Pennsylvania, through S. Powel, Esq.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer's statement for December, 1862, and his annual statement for the year 1862, were read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (6) were proposed, and the candidates (9) proposed at the last meeting were duly elected.

The Tellers of the Annual Election for Officers, Managers, and Auditors for the ensuing year, reported the result, when the President declared the following gentlemen duly elected:

John C. Cresson, President.

John Agnew, }  
Matthias W. Baldwin, } Vice Presidents.

Isaac B. Garrigues, Recording Secretary.

Frederick Fraley, Corresponding Secretary.

John F. Frazer, Treasurer.

#### MANAGERS.

Samuel V. Merrick,  
Thomas Fletcher,  
Edwin Greble,  
Thomas S. Stewart,  
Alan Wood,  
John E. Addicks,  
Isaac S. Williams,  
George W. Conarroe,

Thomas J. Weygandt,  
George Erety,  
Evans Rogers,  
Robert Cornelius,  
James H. Bryson,  
Washington Jones,  
William Harris,  
Joseph Hutchinson,

William A. Drown,  
Coleman Sellers,  
William Weightman,  
James S. Whitney,  
William C. Allison,  
B. Henry Bartol,  
Jacob Naylor,  
Eliashib Tracy.

#### AUDITORS.

Samuel Mason,

James H. Cresson,

William Biddle.

At a meeting of the Board of Managers, held January 28th, 1863, the following officers were elected for the ensuing year:

William Harris, Chairman.

Isaac S. Williams, }  
William A. Drown, } Curators.

Mr. Howson exhibited to the meeting a large number of locks, not, as he said, because there was anything essentially new in most of those exhibited, but in order to show the great number of devices which had been produced in order to make locks that would answer for either right or left-handed doors.

Mr. H. also exhibited an improved burner for coal oil lamps, invented by Emil Tritten. The wick tube is so isolated that although it is firmly attached to the burner, the heat from the flame cannot be

conveyed to the reservoir so as to vaporize and thus waste the oil. An extremely simple and ingenious burner for coal oil lamps, the invention of W. O. B. Merrill, of this city, was also exhibited.

B. F. Joslyn's improved revolving pistol for metallic cartridge, was exhibited by Mr. H. The cylinder of the pistol, on withdrawing the centre pin, may be pushed to one side without entirely detaching it from the frame. The advantage of this is that the pistol may be loaded and the spent cases removed without any liability of losing the cylinder by detaching it. The centre pin passes through a key so connected to the front of the frame that it may also be turned to the side, and the pin pushed back through the openings in the cylinder, thereby forcing out the cases of the discharged cartridges.

A belt fastener, invented by Messrs. Leibrich and Uitting, of this city, was exhibited. Two eccentric rollers, the surface of which are so formed as to present a series of longitudinal ribs having sharp edges, are connected together at the ends by metal plates, in which the journals of the rollers turn. When the surfaces of the rollers are farthest apart, the ends of the strap or belt may be passed upwards between them. On attempting to withdraw the strap, however, the rollers are turned, and the surfaces brought nearer together, securing between them the ends of the belt, which are prevented from slipping out by the sharp edges, or ribs, on the rollers, which hold the ends together with a grip increasing with the force applied to withdraw the ends of the strap.

A combined rule, square, and level, was exhibited by Mr. Howson. The frame of the rule is of metal, filled with vulcanized rubber, which forms in the present instance the body of the instrument, although other substances may be used. By means of a strip of metal, jointed, and contained within the rule, and a spirit-level in a recess in the edge of the same, a number of operations, each heretofore requiring a separate instrument, may be performed.

G. F. Witsel's patent combined washing machine and clothes-wringer was exhibited. In a triangular reservoir vibrates a similarly-shaped dasher, which is so constructed as to form a receptacle for the clothes, which, as the dasher is vibrated, are cleaned by the water which passes through openings in the sides of the dasher and through the interstices of the clothes. The journals of two rubber-covered rollers turn in the opposite sides of the reservoir, and are so situated that the clothes may be taken from the dasher and passed directly between the rollers.

Mr. T. J. Weygandt exhibited a thermo-multiplier, an extremely neat and sensitive instrument, made by himself. The chief merit consists in the compactness, the whole of the essential parts occupying a space but little larger than two cubic inches. Mr. W. stated that a fly on the bars would deflect the needle from three to five degrees.

*A General Abstract of the Meteorological Observations made at Philadelphia during the year 1862.*—By JAMES A. KIRKPATRICK, A. M.  
Latitude, 39° 57' N. Longitude, 75° 10' W. from Greenwich. Height of Barometer fount, sixty feet above mean tide in the Delaware River.

1862. Months.	Thermometer.							Barometer reduced to 32° F.							Dew Point.						
	Maximum.	Minimum.	Range.		Means.			Highest.	Lowest.	Range.		Means.			Average.	Means.					
			Monthly.	Mean daily.	Mean daily.	oscillation.	7 A. M.			2 P. M.	9 P. M.	Average.	7 A. M.	2 P. M.		9 P. M.	Average.	7 A. M.	2 P. M.	9 P. M.	Average.
January,	54	10	44	5.04	10.21	29.36	34.47	31.97	31.93	30.408	29.325	1.083	.261	29.942	29.891	29.931	29.922	23.81	25.23	24.49	24.51
February	52	16	36	5.55	10.89	28.36	36.00	31.64	32.00	30.322	29.216	1.106	.225	29.939	29.891	29.922	29.917	23.08	25.57	25.43	24.69
March,	56	22	34	3.95	14.44	31.22	44.21	39.18	39.21	30.173	29.276	.897	.173	29.801	29.747	29.795	29.782	26.76	28.05	29.86	28.22
April,	82	28	54	5.89	17.87	41.57	55.23	48.28	49.36	30.321	29.422	.899	.146	30.025	29.979	29.991	29.999	34.15	34.34	35.95	34.81
May,	85	40	45	5.77	19.81	57.85	70.08	61.32	63.08	30.058	29.518	.540	.124	29.785	29.740	29.760	29.762	44.89	45.03	46.53	45.48
June,	89	47	42	5.34	17.60	61.57	74.72	66.75	68.68	30.146	29.375	.771	.123	29.738	29.706	29.728	29.724	55.94	56.43	57.91	56.76
July,	95½	53	42½	4.23	17.50	71.13	82.06	73.60	75.60	30.156	29.487	.669	.107	29.743	29.724	29.731	29.733	61.70	60.80	63.41	61.97
August,	95	54	41	3.89	16.56	71.47	82.93	75.13	76.51	30.099	29.557	.542	.122	29.829	29.796	29.818	29.814	61.15	59.16	62.38	60.89
September,	87	48	39	4.30	16.22	63.53	76.03	67.55	69.04	30.086	29.398	.688	.128	29.881	29.845	29.876	29.867	55.82	57.31	59.30	57.48
October,	86	35	51	5.48	15.31	52.70	61.29	56.98	57.99	30.201	29.307	.894	.151	29.865	29.825	29.859	29.850	46.31	48.85	48.21	47.79
November,	71	27	44	5.94	13.40	40.67	48.18	43.25	44.03	30.555	29.380	1.175	.159	29.877	22.823	29.870	29.857	34.64	35.95	35.70	35.43
December,	64	8	56	6.46	12.74	32.24	39.76	34.71	35.57	30.495	29.319	1.176	.197	29.932	29.895	29.926	29.921	26.45	27.27	27.55	27.09
Annual means,	95½	8	87½	5.15	15.21	49.22	59.00	52.53	53.58	30.555	29.216	1.339	.160	29.863	29.822	29.852	29.846	41.22	42.00	43.06	42.09
Winter,	64	10	54	5.42	11.89	30.08	37.58	33.16	33.60	30.462	29.216	1.246	.233	29.973	29.926	29.955	29.951	21.60	26.76	26.57	25.98
Spring,	85	22	63	5.20	17.37	45.55	56.51	49.59	50.55	30.321	29.276	1.045	.148	29.871	29.822	29.850	29.848	35.27	35.81	37.44	36.17
Summer,	95½	47	48½	4.16	17.22	69.06	79.90	71.83	73.60	30.156	29.375	.781	.117	29.770	29.742	29.759	29.757	59.60	58.80	61.23	59.87
Autumn,	87	27	60	5.24	14.98	52.30	62.83	55.93	57.02	30.555	29.307	1.248	.146	29.874	29.831	29.868	29.858	45.59	47.37	47.74	46.90
Means for 11 years,	100½	—5½	106	5.57	15.19	49.69	59.96	53.14	54.26	30.701	28.824	1.820	.156	29.890	29.850	29.874	29.871				43.52

TABLE (Continued).—A General Abstract of the Meteorological Observations made at Philadelphia during the year 1862.

1862. Months.	Relative Humidity.						Force of Vapor.						Clouds. Sky covered.				Rain or melted snow.		Winds.	
	Means.						Means.						Means.				Amount.	No. of days it fell.	Monthly resultant.	No. of times in 1000.
	Range.			Average.			Range.			Average.			Means.							
	Maximum.	Minimum.	Per ct.	7 A. M.	2 P. M.	9 P. M.	Maximum.	Minimum.	Inch.	7 A. M.	2 P. M.	9 P. M.	Average.	Pr. ct.	Pr. ct.	Pr. ct.	Days	Direct from.		
January,	100	32	68	80.0	70.7	75.4	.275	.051	.224	.134	.145	.142	.140	74.8	73.5	73.9	74.1	16	N 18° 26' W	
February,	100	44	56	80.4	66.6	77.9	.267	.060	.207	.130	.143	.142	.138	76.1	73.2	73.1	70.1	15	N 45 0 W	
March,	95	25	70	74.4	56.2	70.5	.389	.081	.308	.149	.159	.171	.159	62.3	66.1	65.8	64.7	11	N 43 7 W	
April,	91	18	76	67.8	48.5	64.5	.555	.091	.464	.211	.219	.228	.219	68.7	67.3	67.3	64.6	11	N 45 0 E	
May,	93	18	75	64.2	44.9	60.3	.555	.091	.464	.211	.219	.228	.219	68.7	67.3	67.3	64.6	11	N 45 0 E	
June,	94	33	61	71.7	55.5	74.3	.682	.180	.590	.463	.470	.498	.477	71.7	66.7	50.7	62.9	9	N 53 37 W	
July,	97	36	61	72.7	49.7	71.0	.645	.180	.590	.463	.470	.498	.477	71.7	66.7	50.7	62.9	15	N 79 23 W	
August,	87	30	57	70.5	45.6	65.4	.605	.180	.590	.463	.470	.498	.477	71.7	66.7	50.7	62.9	10	S 58 24 W	
September,	97	32	65	77.1	54.0	75.4	.688	.211	.622	.465	.490	.519	.491	58.7	49.7	45.3	51.2	7	S 90 0 W	
October,	97	33	64	79.5	59.7	73.5	.709	.133	.562	.310	.378	.365	.361	53.9	51.9	49.3	51.7	6	N 4 5 E	
November,	100	37	63	79.4	64.5	75.1	.730	.106	.442	.213	.228	.224	.222	64.0	64.3	63.7	64.0	11	N 73 30 W	
December,	92	31	61	78.5	61.5	71.8	.716	.010	.337	.154	.163	.162	.160	52.6	58.7	42.6	51.2	15	N 79 0 W	
Annual means,	100	18	82	74.9	56.4	71.5	.676	.010	.899	.308	.316	.330	.318	62.9	62.8	52.5	59.1	8	S 84 24 W	
Winter,	100	23	77	80.0	66.4	77.3	.746	.051	.339	.140	.154	.152	.149	70.3	67.5	56.1	61.6	134	N 58 40 W	
Spring,	95	18	77	68.8	49.9	65.1	.613	.081	.513	.227	.234	.245	.235	63.6	64.6	51.9	60.0	35	N 47 35 W	
Summer,	97	30	67	72.6	50.3	70.2	.614	.099	.759	.529	.513	.559	.533	61.1	62.8	46.1	56.7	31	N 48 18 W	
Autumn,	100	32	68	78.7	59.4	74.7	.709	.833	.106	.727	.339	.365	.358	58.8	55.3	52.8	55.6	32	S 72 58 W	
Means for 11 years,	100	13	87	76.1	57.5	72.4	.687	.059	.1046	.324	.341	.345	.337	59.5	60.0	44.8	54.8	32	N 74° 29' W	

*A Comparison of some of the Meteorological Phenomena of DEC., 1862, with those of DEC., 1861, and of the same month for TWELVE years, at Philadelphia, Pa.*  
 Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½' N.; Longitude 75° 10½' W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	December, 1862.	December, 1861.	December, 12 Years.
Thermometer—Highest—date, . . .	15th.	10th.	2d, 1859.
“ “ degree, . . .	64·00°	64·00°	71·00°
“ Warmest day—Date, . . .	15th.	9th.	2d, 1859.
“ “ Mean, . . .	55·00	54·20	62·80
“ Lowest, date, . . .	21st.	4th and 26th.	19th, 1856.
“ “ degree, . . .	8·00	19·00	4·50
“ Coldest day—date, . . .	20th.	28th.	18th, 1856.
“ “ Mean, . . .	15·83	26·50	11·00
“ Mean daily oscillation, . . .	12·74	11·58	12·28
“ “ range, . . .	6·46	5·66	6·37
“ Means at 7 A. M., . . .	32·24	32·52	31·77
“ “ 2 P. M., . . .	39·76	42·26	39·26
“ “ 9 P. M., . . .	34·71	35·88	34·58
“ “ for the Month, . . .	35·57	36·88	35·20
Barometer—Highest—Inches, . . .	30·495 in.	30·462 in.	29·678 in.
“ “ date, . . .	20th.	13th.	18th, 1856.
“ Greatest mean daily press., . . .	30·401	30·413	30·611
“ “ date, . . .	20th.	12th.	18th, 1856.
“ Lowest—Inches, . . .	29·319	29·292	28·916
“ “ date, . . .	16th.	23d.	9th, 1855.
“ Least mean daily pressure, . . .	29·507	29·411	29·175
“ “ date, . . .	16th.	23d.	9th, 1855.
“ Mean daily range, . . .	0·197	0·213	0·211
“ Means at 7 A. M., . . .	29·932	30·040	29·959
“ “ 2 P. M., . . .	29·895	29·992	29·920
“ “ 9 P. M., . . .	29·936	30·012	29·945
“ “ for the Month, . . .	29·921	30·015	29·941
Force of Vapor—Greatest—Inches, . . .	0·377 in.	0·390 in.	0·551 in.
“ “ “ date, . . .	15th.	9th.	2d, 1859.
“ “ Least—Inches, . . .	·040	·069	·025
“ “ “ date, . . .	20th.	15th.	18th, 1856.
“ “ Means at 7 A. M., . . .	·154	·155	·143
“ “ “ 2 P. M., . . .	·163	·175	·168
“ “ “ 9 P. M., . . .	·162	·173	·155
“ “ “ for the month, . . .	·160	·168	·155
Relative Humidity—Greatest per cent., . . .	92· per ct.	95·0 per ct.	100· per ct.
“ “ “ date, . . .	14th.	7th, 18th, 23d.	Often.
“ “ Least per cent, . . .	31·	23·0	23·0
“ “ “ date, . . .	2d.	15th.	15th, 1861.
“ “ Means at 7 A. M., . . .	78·5	79·5	77·4
“ “ “ 2 P. M., . . .	61·5	61·9	65·8
“ “ “ 9 P. M., . . .	74·8	78·5	75·5
“ “ “ for the month, . . .	71·6	73·3	72·9
Clouds—Number of Clear days,* . . .	13	13	9·
“ “ Cloudy days, . . .	18	18	22·
“ Means of sky cov'd at 7 A. M., . . .	52·6 per ct.	60·0 per ct.	63·9 per ct
“ “ “ 2 P. M., . . .	58·7	55·8	63·3
“ “ “ 9 P. M., . . .	42·6	33·2	46·0
“ “ “ for the month, . . .	51·2	73·3	57·7
Rain and melted Snow—Amount . . .	1·555 in.	2·061 in.	3·527 in.
No. of days on which Rain or Snow fell, . . .	8·	4·	9·9
Prevailing Winds, . . .	N84°24'W·301	N74°3'W·383	N·59°20'W·299

\* Less than one-third covered at the hours of observation.

*A Comparison of some of the Meteorological Phenomena of the year 1862, with those of 1861, and of the last ELEVEN years, at Philadelphia, Pa.*

	1862.	1861.	11 Years.
Thermometer.—Highest,—date,	July 7th.	July 8th.	July 21, 1854.
“ “ degree,	95·5°	95·00°	100·50°
“ Warmest day—date,	Aug. 9th.	July 8th.	July 21, 1854.
“ “ “ Mean,	87·67	87·80	91·30
“ Lowest—date,	Dec. 21st.	Feb. 8th.	Jan. 23, 1857.
“ “ degree,	8 00	— 1·00	— 5·50
“ Coldest day—date,	Dec. 20th.	Jan. 13th.	Jan. 9, 1856.
“ “ “ Mean,	15·83	7·80	— 1·00
“ Mean daily oscillation,	15·21	16 85	15·19
“ “ “ range,	5·15	5·57	5 57
“ Means at 7 A. M.,	49·22	50·15	49·69
“ “ 2 P. M.,	59·00	60·74	59·96
“ “ 9 P. M.,	52·53	53·24	53 14
“ “ for the year,	53 58	54·71	54·26
Barometer.—Highest—Inches,	30·555 in.	30·526 in.	30·704 in.
“ “ date,	Nov. 16th.	Jan. 23d.	Jan. 28, 1853.
“ Greatest daily mean press.,	30·509	30·483	30·611
“ “ date,	Nov. 16th.	Jan. 23d.	Dec. 18, 1856.
“ Lowest, Inches,	29·216	29 096	28·884
“ “ date,	Feb. 24th.	May 27th.	Ap. 21, 1852.
“ Least daily mean pressure,	29·390	29·243	28·959
“ “ date,	March 16th.	May 27th.	Ap. 21, 1852.
“ Mean daily range,	0·160	0·167	0·156
“ Means at 7 A. M.,	29·863	29·890	29·890
“ “ 2 P. M.,	29·822	29·845	29 850
“ “ 9 P. M.,	29·852	29·870	29·874
“ “ for the year,	29·846	29 868	29·871
Force of Vapor.—Greatest—Inches,	0 939 in.	0 841 in.	1·059 in.
“ “ “ date,	Aug. 8th.	Aug. 5th.	June 30, 1855.
“ “ Least—Inches,	·040	·023	·013
“ “ “ date,	Dec. 20th.	Feb. 8th.	Feb. 6, 1855.
“ “ Means at 7 A. M.,	·308	·319	·324
“ “ “ 2 P. M.,	·316	·332	·341
“ “ “ 9 P. M.,	·330	·343	·345
“ “ “ for the year,	·318	·331	·337
Relative Humidity.—Greatest per cent.,	100· per ct.	100· per ct.	100· per ct.
“ “ “ date,	Often.	Often.	Often.
“ “ Least per cent,	18·0	18·0	13·0
“ “ “ date,	Ap. 27; May 8	May 2d,	Ap. 13, 1852.
“ “ Means at 7 A.M.,	74·9	74·8	76·1
“ “ “ 2 P.M.,	56·4	54·9	57·5
“ “ “ 9 P.M.,	71·5	72·5	72·4
“ “ “ for the year,	67·6	67·4	68·7
Clouds—Number of Clear days,*	100 days.	109 days.	111·7 days.
“ “ Cloudy days,	265 days.	256 days.	253·5 days.
“ Means of sky cov'd at 7 A. M.,	62 9 per ct.	58·7 per ct.	59·5 per ct.
“ “ “ 2 P. M.,	62·8	61·6	60 0
“ “ “ 9 P. M.,	52·5	46 2	44·8
“ “ “ for the year,	59·4	55 5	54·8
Rain and melted Snow—Amount,	45·656 in.	46·414 in.	44·936 in.
No. of days on which Rain or Snow fell,	134·	125·	127·
Prevailing winds,	N 53° 40' W 159	N 81° 41' W 239	N 74° 29' W 227

\* Less than one-third covered at the hours of observation.

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CIVIL ENGINEERING.

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*On the Construction of Iron Roofs.* By Mr. J. J. BIRCKEL.

From the London Artizan, August, 1862.

THE rapid introduction of iron in place of wood in the construction of roofs will, we believe, cause our readers to consider the study of the construction of iron roofs as being worthy of their careful attention, and the interest with which they will peruse the subject will, no doubt, be greatly enhanced when we shall point out its bearings upon the security of human life and property.

In order to give our readers a clear insight into this subject, we will first deal with the theoretical questions which it embraces; and, divesting these of all unnecessary scientific difficulties, enable them to learn what should be done in any given case. We shall afterwards lay before them different existing examples of roofs, which will enable them to see what has been done under various circumstances, and which may serve to them as guides in their own future practice.

A roof is, generally, a series of trussed frames, so constructed as that their shape shall not be able to alter; and which, for the convenience of calculation, are supposed to be under the influence of vertical parallel pressures, some of which are permanent, and some casual. The permanent pressures are the weight of the structure of the roof, including frames and covering, and the casual pressures are those of wind, hail, snow, or rain, against all of which provision should be

made. For the sequel, we shall see what are their respective amounts as generally admitted.

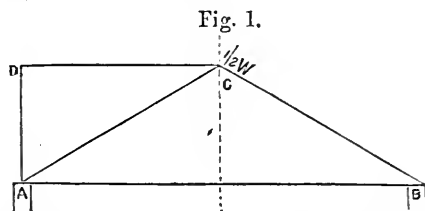


Fig. 1 represents the simplest kind of truss to be met with in roofs of small spans, and consisting of two struts  $AC$ ,  $BC$ , called rafters, and of a tie rod  $AB$ ; the frame as a whole is called a principal. Let  $w$  represent the whole load on one division of the roof, extending between two consecutive principals, the weight on each rafter will be  $\frac{1}{2} w$ , and may be supposed to be collected at the points  $A$  and  $C$ ,  $B$  and  $C$ , so that the weight directly supported at the points  $A$  and  $B$  is  $\frac{1}{4} w$ , and at the point  $C$   $\frac{1}{2} w$ ; this latter portion is transmitted in equal amounts to the walls or supports, which accordingly sustain each a pressure of  $\frac{1}{2} w$ . With the assistance of the theory of parallel projections, so fully illustrated by Professor Rankine, it will now be easy to define the stress on each component part of the principal; for if  $AD$  be made to represent  $\frac{1}{4} w$ ,  $AC$  will represent the thrust upon the rafter, and  $DC$  the pull upon the tie rod, whence the following:—

In the case of a principal, constructed in the shape of a simple triangular truss, if the rise of the roof be made to represent one-fourth the load on one division of the roof, the thrust on the rafter will be represented by its own length, and the pull on the tie rod by one-half its own length.

This, to be sure, is simple enough; and when we remember that the load on the roof is an assumed one, we may safely say that the results thus obtained are quite as correct as those obtained by means of trigonometric calculations. But, if we must have trigonometric formulæ, we would prefer to have them in a shape which would enable us to solve them by simple reference to a table of sines and tangents; for, as homely practitioners, we are not likely to have at our fingers ends all the transformations which trigonometric formulæ admit of; and, while we have to search in a treatise on trigonometry, we might be usefully employed solving the practical problem upon which we are engaged. The formulæ for the case under the consideration as given by Professor Rankine in his *Treatise on Practical Mechanics*, are as follows:—Let  $H$  be the pull on the rod,  $R$  the thrust on the rafter, and  $i$  the angle, which the latter makes with the horizon, then—

$$H = \frac{1}{4} \frac{w}{\tan. i} \text{ and } R = \frac{1}{4} w \operatorname{cosec.} i.$$

Here we have no difficulty in dealing with the first formula; for we find  $\tan. i$  or  $\log. \tan. i$  in any trigonometric table; but  $\operatorname{cosec.} i$  is generally ignored by those tables; and before we can solve the second formula, we must find out what relation  $\operatorname{cosec.} i$  bears to  $\sin. i$ , to  $\cos. i$ ,



or to tang.  $i$ . On that ground, we would prefer Moseley's formulæ :

$$R = \frac{1}{4} \frac{W}{\sin. i}$$

which is, indeed, its natural and legitimate form. General Morin, who devotes a considerable space to the subject of construction of roofs in his work on resistance of materials, gives two different values to the pull  $H$  on the tie rod. Looking, first, upon the rafter as an isolated beam, subject to the action of an equally distributed load in its length, and at its lower end to the reactions of the wall and of the tie rod, he arrives at the value of  $H$ , by imposing upon himself the condition that the deflection of the rafter shall be null, and thus obtains the formula :

$$H = \frac{1}{2} W \frac{5}{8} \text{ tang. compl. } i = \frac{5}{16} \frac{W}{\text{tang. } i}.$$

In a subsequent article on the same subject, proceeding to determine the value of  $H$ , by a method similar to Rankine's method of section, he finds,

$$H = \frac{1}{4} \frac{W}{\text{tang. } i}$$

which formula is identical with the one quoted in the first instance. Here, then, there is a difference of  $\frac{1}{16}$  in the values of  $H$  given by Gen. Morin ; and as we can detect no errors of calculus, we must look for the origin of that difference ; we think, in that previous part of his work in which he deals with the absolute deflection of beams, the formulæ there obtained being here made use of. As the difference is one of excess, however, we have no occasion to quarrel with this author about it, but have pointed it out rather for the purpose of showing that elaborate algebraic calculations may lead to results quite as much at variance with each other as plain geometric manipulations.

Fig. 2.

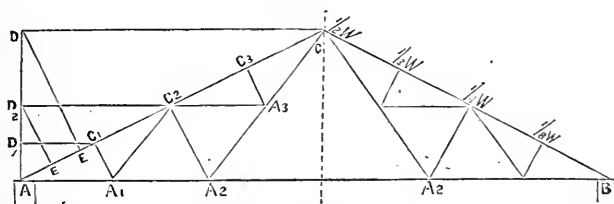


Fig. 2 represents a system of trussing which occurs frequently in iron roofs of large spans.  $ABC$  is the primary truss, consisting of the rafters  $AC$ ,  $BC$ , and of the tie rod  $AB$ . The rafter is supported in its centre by a secondary truss  $ACA_2$ , consisting of the rafter itself, of the two ties  $AA_2$ ,  $CA_2$ , and of the strut  $C_2A_2$ ; at the intermediate points  $C_1$ ,  $C_3$ , it is supported also by two minor secondary trusses  $AC_2A_1$  and  $CC_2A_3$ , similar to the one just described and supported by it. The stresses sustained by the component parts of each individual truss must be determined as if that truss was an independent structure ; and to

be able to do that we must see how the load is distributed upon the points  $A, C_1, C_2, C_3, C$ , which will be arrived at in the following manner:  $\frac{1}{2} w$  being equally distributed upon each rafter, the load directly supported at the points  $C_1, C_2, C_3$ , is  $\frac{1}{8} w$ , and the load at each point  $A$  and  $B$  is  $\frac{1}{16} w$ ; but the minor secondary trusses, through their tension rods, exert a pressure of  $\frac{1}{8} w$ , at the point  $C_2$ , and of  $\frac{1}{16} w$  at each of the points  $A$  and  $B$ ; the major secondary truss exerts a pressure of  $\frac{1}{8} w$  at each of the points  $A$  and  $B$  also, so that the final distribution of the load is, at  $C \frac{1}{2} w$ , at each of the points  $A, B$  and  $C_2 \frac{1}{4} w$ , and at the points  $C_3 \frac{1}{8} w$ .

Let  $A D$  again represent  $\frac{1}{4} w$ , then  $D C = H$  will represent the stress on the horizontal rod, arising from the primary truss;  $D_2 C_2 = H_2$  the stress on the ties of the major secondary truss, and  $D_1 C_1 = H_1$ , the stress on the tie rods of the minor secondary trusses. The thrust on the rafter arising from the primary truss is represented by its own length  $A C = R$ ; that on the lower half of the rafter due to the major secondary truss is represented by  $A C_2 = R_1$ , and on the upper half by  $H C_2 = R_2$ , the difference here arising from the component along the rafter of the weight applied at the points  $C_2$ ; the stress on the lower half of each portion of the rafter forming part of the minor secondary trusses and arising from the same is  $A C_3 R_3$ , and that on the upper halves  $C_1 E_1 = R_4$ . The resultant stresses on the various parts of the frames, therefore, will be:—

*Pull on the Horizontal Tie Rod.*

Between  $A \ A_1 = H + H_2 + H_1$

"  $A_1 + A_2 = H_1 + H_2$

"  $A_2 A_3 = H$

*Rankine's Formulæ.*

$$\frac{w}{\text{tang. } i} \left( \frac{1}{4} + \frac{1}{8} + 1.16 \right)$$

$$\frac{w}{\text{tang. } i} \left( \frac{1}{4} + \frac{1}{8} \right)$$

$$\frac{w}{\text{tang. } i} \left( \frac{1}{4} \right)$$

*Thrust on the Rafters.*

Between  $A \ C_1 = R + R_1 + R_3$

"  $C_1 C_2 = R + R_1 + R_4$

"  $C_2 C_3 = R + R_2 + R_3$

"  $C_3 C = R + R_2 + R_4$

*Rankine's Formulæ.*

$$w \text{ cosec. } i \left( \frac{1}{4} + \frac{1}{8} + 1.16 \right)$$

$$w \text{ cosec. } i \left( \frac{1}{4} + \frac{1}{8} + 1.16 - \frac{1}{8} \sin^2 i \right)$$

$$w \text{ cosec. } i \left( \frac{1}{4} + \frac{1}{8} + 1.16 - \frac{1}{4} \sin^2 i \right)$$

$$w \text{ cosec. } i \left[ \frac{1}{4} + \frac{1}{8} + 1.16 - \sin^2 i \left( \frac{1}{4} - \frac{1}{8} \right) \right]$$

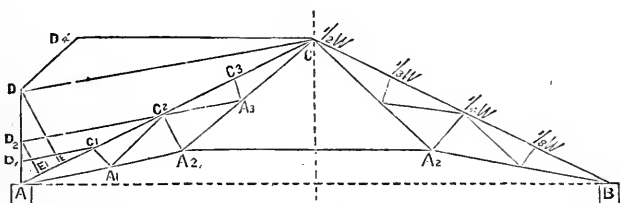
The thrust on the struts  $C_2 A_2$  is represented by  $D E$ , and that on the struts  $C_1 A_1$  and  $C_3 A_3$  by  $D_2 E_1$ .

These various results, rendered in an algebraic form, would be identical with those given by Professor Rankine, which we have transcribed for inspection by the curious; but as these formulæ are rather complicated, and necessitate the use of the trigonometric tables, the diagram of forces which we have here given will be found far more useful in practice.

As the rafters are generally of uniform strength throughout their length, it will be sufficient to define the maximum thrust upon them, and it will be sufficient also to define the minimum and the maximum pull on the tie rod, and the maximum pull on the braces. A careful investigation of the diagram will show that in the case of a principal,

trussed in the manner illustrated by fig. 2, if the rise of the roof be made to represent one-fourth the load on one principal, the maximum thrust on the rafter is represented by  $\frac{7}{4}$  its own length; the minimum pull on the tie rod by  $\frac{1}{2}$ ; and the maximum pull by  $\frac{7}{8}$  its own length; the maximum pull on the braces is represented by  $\frac{3}{8}$  the length of tie rod. Should the minor secondary trusses be left out, the maximum thrust on the rafter will be represented by  $\frac{6}{4}$  its own length; the maximum pull on the tie rod by  $\frac{3}{4}$  its own length; and the maximum pull on the braces by  $\frac{1}{4}$  the length of the tie rod.

Fig. 3.



Very often, however, the tie rod is raised above the horizontal, and then the diagram of forces assumes a somewhat altered shape. Fig. 3 is an illustration of this case, and the distribution of the load being as previously, if from the point  $C$  we draw  $CD$  parallel to  $AA_2$ ,  $DA$  will stand for  $\frac{1}{4} W$ ;  $CD$  will represent the pull on the tie  $AA_2$ ;  $CD_4$ , which is horizontal, will represent the pull on the tie  $A_2A_2$ ;  $DD_4$ , parallel to the brace  $CA_2$ , will represent the pull on the same, and  $AC$  the thrust on the rafter; all these being due to the primary truss only. The stresses arising from the secondary trusses will be determined as previously, by drawing  $C_2D_2$  and  $C_1D_1$  parallel to  $AA_2$ ; and  $DH$ ,  $D_2H_1$ , perpendicular to the rafter; finally, the resultant stresses are to be computed as before, care being taken not to omit the additional stress  $DD_4$  on the braces.

Fig. 4.

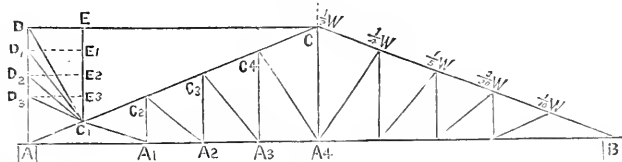


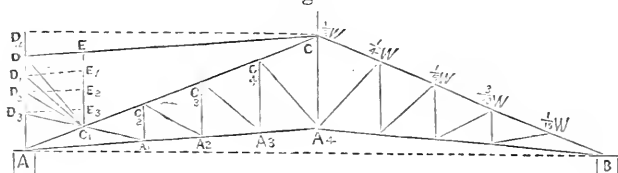
Fig. 4 represents a system of trussing very generally adopted, and roofs so constructed are known by the name of king and queen post roofs. The number of secondary trusses to support the rafter varies according to the span; and, in the present case, it is supported by four of these, which are  $A A_1 C_1 A A_2 C_2 A A_3 C_3 A A_4 C_4$ , and the stresses again must be determined for each separately. Here the distribution of the load is as follows:— $\frac{1}{5}$  of the weight on the rafter, or  $\frac{1}{10} W$  rests directly on each of the points  $C_1, C_2, C_3, C_4$ , and  $\frac{2}{10} W$  at  $A$  and at  $C$ ; but by means of the vertical ties connecting the trusses one-half the weight at  $C_1$  is transmitted to  $C_2$ ;  $\frac{2}{3}$  of the load at  $C_2$  is transmitted to

$c_3$ ,  $\frac{3}{4}$  of the load at  $c_3$  to  $c_4$  and  $\frac{1}{2}$  of that at  $c_4$  to  $c$ ; so that, finally, we have;—At  $c$   $\frac{1}{10} W$ ; at  $c_2$   $\frac{3}{20} W$ ; at  $c_3$   $\frac{1}{5} W$ ; at  $c_4$   $\frac{1}{4} W$ ; and at  $c$   $\frac{1}{2} W$ . If the rise of the roof be made to represent  $\frac{1}{4} W$ ,  $DC = H$  will represent the pull on the tie rod, and  $AC = R$  the thrust on the rafter, as due to the primary truss. To determine the stress upon the component parts of each secondary truss from the point  $c_1$ , let us draw the line  $c_1 D$  parallel to the strut  $c_4 A_4$ ,  $c_1 D_1$  parallel to  $c_3 A_3$ ,  $c_1 D_2$  parallel to  $c_2 A_2$ , and  $c_1 D_3$  parallel to  $c_1 A_1$ . These lines will respectively represent the thrust upon the struts to which they are parallel:  $DE = H_1$  represents the pull on the tie rod, and  $AC_1 = R_1$  the thrust upon the rafter, as due to each secondary truss. It is worth noticing here, that, in this system of trussing, the two latter stresses remain constant for each secondary truss.  $c_1 E_3$ ,  $c_1 E_2$ ,  $c_1 E_1$ , respectively, represent the pull on the vertical ties  $A_1 C_2$ ,  $A_2 C_3$ ,  $A_3 C_4$ ; and  $c_1 E$  represents one-half the pull on the king post  $A_4 C$ , the pull here being double that shown by the diagram of forces, because the resultant stress from the corresponding truss on the other rafter is also thrown upon this rod. The resultant stresses, therefore, are as follows:—

<i>Pull on the Tie Rod.</i>		<i>Thrust on the Rafter.</i>	
Between $A_3 A_4 = S + S_1$		Between $c c_4 = T$	
“ $A_2 A_3 = S + 2 S_1$		“ $c_3 c_4 = T + T_1$	
“ $A_1 A_2 = S + 3 S_1$		“ $c_2 c_3 = T + 2 T_1$	
“ $A A_1 = S + 4 S$		“ $c_1 c_2 = T + 3 T_1$	
		“ $A c_1 = T + 4 T_1$	

And the maximum stresses are, for the pull on the tie rod, represented by  $\frac{9}{10}$  its own length, and for the thrust on the rafter by  $\frac{9}{5}$  its own length; but if the number of secondary trusses on each rafter were reduced to three, the maximum stresses would be as in the trussing illustrated by fig. 2; viz. the thrust on the rafter represented by  $\frac{7}{4}$  its own length, and the pull on the tie rod by  $\frac{7}{8}$  its own length.

Fig. 5.



In this system of trussing, also, the tie rod is generally raised out of the horizontal line, as shown by fig. 5, and the diagram of forces, which, it may be well to state, hold good for any number of secondary trusses, undergoes a slight modification. In this case  $CD$  is to be drawn parallel to  $AA_4$ , and  $AD = CA_4$  is to stand for  $\frac{1}{4} W$ ;  $CD$  then will represent the pull on the tie rod,  $AC$  the thrust on the rafter, and  $2DD_4$  the pull on the king post, as arising from the primary truss. The stresses due to the secondary trusses, as also the resultant stresses, will now be determined as previously, care being taken not to omit the quantity  $2DD_4$ , in computing the pull on the king post.

As an example of the application of the foregoing, let us determine the stresses on the various parts of a roof supposed to have a span of 50 feet, with a rise of 10 feet, the principals being 15 feet apart, and trussed according to the method illustrated by fig. 2. If we assume the load to be 40 pounds per square foot, we shall have  $\frac{1}{4}w = 3.6$  tons, and each lineal foot will represent a pressure of 0.36 tons. The minimum pull on the tie rod will be

$$H = 0.36 \text{ tons} \times \frac{50}{2} = 9 \text{ tons.}$$

The maximum pull

$$H + H_2 + H_1 = 0.36 \text{ tons} \times 50 \times \frac{7}{8} = 15\frac{3}{4} \text{ tons.}$$

The maximum pull on the braces

$$H_2 + H_1 = 0.36 \text{ tons} \times 50 \times \frac{3}{8} = 6\frac{3}{4} \text{ tons.}$$

And the pull on the ties of the minor trusses

$$H_1 = 0.36 \times 50 \times \frac{1}{8} = 2\frac{1}{4} \text{ tons.}$$

Which for a unit stress of 5 tons per square inch of section would give the following scantlings:—

for the middle portion of the tie rod  $\frac{9}{5} = 1.8 \text{ sq. in.} = 1\frac{1}{2} \text{ in. rod.}$

for the ends  $\frac{15.75}{5} = 3.15 \text{ sq. in.} = 2 \text{ in. rod.}$

for the braces  $\frac{6.75}{5} = 1.35 \text{ sq. in.} = 1\frac{5}{16} \text{ in. rod.}$

and for the small ties  $\frac{2.25}{5} = 0.45 \text{ sq. in.} = \frac{3}{4} \text{ in. rod.}$

The length of the rafter is 27 feet, and the maximum thrust on it will be

$$R + R_1 + R_3 = 0.36 \text{ tons} \times 25 \times \frac{7}{4} = 17 \text{ tons.}$$

Which, for a load of 5 tons to the square inch, would give an area of  $3\frac{1}{2}$  square inches. Here, however, we must remember that the rafter is not only a strut, but that it is also a beam, subject to deflection by a bending moment, whose value, in the present instance, is

$$M = \frac{1}{84} \times 7.2 \text{ tons} \times 25 \text{ ft.} \times 12 \text{ in.}$$

where the factor  $\frac{1}{84}$  arises from the fact of the rafter being a continuous beam, supported in three points, and whose ends cannot take any deflection. Under these circumstances, the rafter should be made subject to the condition expressed by the following formula:—

$$s = \frac{R + R_1 + R_3}{A} + \frac{Md_1}{I} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

where  $s$  stands for the unit strain,  $A$  the transverse area of the rafter,  $I$  the moment of inertia of the cross-section and  $d_1$  the distance of the fibre farthest removed from the centre of gravity of that transverse section. Now rafters are generally made of two angle irons, bolted

together back to back, or of **T** iron, and for either of these sections we can write, with sufficient accuracy, for all practical purposes

$$\frac{I}{d_1} = \frac{1}{4.5} A d$$

where  $d$  stands for the whole depth of the **L** or **T** iron.

For the case under consideration, therefore, formula (1) would read thus :

$$s = 5 \text{ tons} = \frac{17 \text{ tons}}{A} + \frac{7.2 \text{ tons} \times 25 \text{ ft.} \times 12 \text{ in.} \times 4.5}{64 \cdot A d} \dots (2)$$

and assuming  $d$  at  $5\frac{1}{2}$  inches, would give for the value of  $A$  :

$$A = \frac{17 \text{ tons}}{5} + \frac{7.2 \text{ tons} \times 25 \text{ ft.} \times 12 \text{ in.} \times 4.5}{64 \times 5 \times 5.5} = 8\frac{1}{2} \text{ sq. in.}$$

equivalent to two **L** irons bolted back to back, each  $5\frac{1}{2} \text{ in.} \times 2\frac{1}{2} \text{ in.} \times \frac{9}{16}$ .

Professor Rankine does not caution his readers about the important fact that the rafter is to be treated as a beam subject to deflection by transverse strain, but simply makes it known as a *strut*, and defines the amount of the thrust, which, under certain circumstances, it will have to resist. The above calculation, however, shows that the area required to resist the thrust is  $3\frac{1}{2}$  square inches only against 5 square inches required to resist the bending moment, and conclusively shows that a roof, calculated in strict accordance with the formulæ given by Professor Rankine, would be ridiculously deficient of strength in one of its most important parts. Possibly, however, he did not so much intend to give a theory of the stability of roofs, as to adduce examples of trussed frames of which he treats especially in that chapter; but in regard to this, we must observe that authors of his class, who are acknowledged and who acknowledge themselves leaders in mechanical science will be held responsible for any mishaps that may or shall arise from certain questions having been treated incompletely, in those of their works written for the use and guidance of practical men.

General Morin, who, among a certain class of his countrymen, has the reputation of being too careful and too heavy in his practical formulæ, strange to say, errs upon this subject in a manner similar to Professor Rankine. Starting with the correct assumption that the rafter is to be considered as an oblique beam under uniform load, and subject at the same time to a certain thrust from the reaction of the tie rod, he lays down a formula, which, containing both these elements of stress would lead to a perfectly correct result; but without any closer investigation of the subject, he then assumes it as an *a priori* fact that the element of stress, arising from the thrust, will always be so small as to be of no material consequence, and wipes out in his formula that part of it providing for the same. We have seen, however, that, in the calculations of the example chosen, the proportion of area arising from the thrust, is to that arising from the moment of flexion as 7 is to 10; and in cases where the trussing is carried still further these relative amounts would approach more and more to an equality,

plainly showing that the *a priori* assumption, upon which Gen. Morin has based his subsequent calculations, is altogether erroneous, and fraught with dangerous consequences.

We earnestly hope that this author, generally so careful and so practical, will be made alive to the error which we have just pointed out, and that before any considerable mischief is done he will revise his elaborate tables on the scantlings of rafters, for the benefit of all those whom it may concern.

(To be Continued.)

### *The Economic Construction of Girders.*

From the Lond. Civ. Eng. and Arch. Jour., Oct., 1862.

(Continued from page 85.)

*Girders of Great Spans.*—The striking conclusions arrived at in our last paper will, we believe, be readily acquiesced in by those who are at the same time sufficiently acquainted with the practical requirements, and have thoroughly studied the simple mathematical questions, involved in the determination of the weights of great girder bridges. But many readers, to whom the results may be surprising and interesting, may not care to follow the processes by which these have been attained, and cannot therefore have clear impressions of the causes of such great disparities in the weights of girders when extreme spans are attempted. We shall therefore endeavor to give here a more direct and sufficiently simple exposition of the excessive influence which the value of the economic merit of any particular form of structure has upon its weight when the dimensions are greatly increased.

*Familiar Exposition of the Relation between Span and Weight of Girder Bridges.*—Let the general factor of safety be assumed, for the sake of simplicity, the same for all spans.

Let  $P$  represent the whole load belonging to one line of railway exclusive of the weight of the bare girders required for its support.  $P$  includes a movable loading at the rate of 1 ton per foot of span besides the weight of the shares of the roadway platform, horizontal and transverse bracings, permanent way, &c., of the complete structure, due to one line of railway.

Let  $G$  represent the weight of the bare girder or girders required to support the above loadings, besides its own weight.

Then  $G + P$  represents the whole load supported, and therefore the whole practical strength required, of the girder or girders.

Then  $G$  represents the portion of the practical strength of the girder not usefully available, being devoted to sustaining the girder itself.

And  $P$  represents the useful strength, or the portion of the practical strength available for the support of the necessary load.

Now let us assume that for a span of 50 feet the weight of the train, roadway platform, &c., or  $P$ , amounts to 65 tons; and let us suppose that two girders constructed on different systems,  $A$  and  $B$ —and each

capable of supporting, under the proper factor of safety, its own weight in addition to the above 65 tons—weight respectively 4 and 6 tons: we then have

	$G + P$ , or Whole Practical Strength.	$G$ , or Strength Self-absorbed.	$P$ , or Available Strength.
Girder built on {	69 tons	4 tons	65 tons
System A, {	or as $17\frac{1}{4}$ to	1 to	$16\frac{1}{4}$
Girder built on {	71 tons	6 tons	65 tons
System B, {	or as 11.5-6 to	1 to	10.5-6

Now since the weights of similar girders are as the *cubes* of their spans, while their strengths (measured by the whole of the supported loads) are only as the *squares* of their spans, it follows that the ratio of the weight of a girder to its strength, or of  $G : G + P$ , varies inversely as the span, or in other words, the ratio of  $G : \text{span } (G + P)$  is constant. Furthermore, these ratios are not materially affected by moderate changes in the absolute strength of the girders, since, within practical limits, a girder which does not vary in span, depth, or design, but only in the general scantlings or sectional areas of the parts, will have its strength varying in the proportion of its weight. Therefore if we increase the above spans from 50 to 400 feet, the ratios of  $G : G + P$ , shown above as  $1 : 17\frac{1}{4}$  and  $1 : 11\frac{5}{8}$ , do respectively become

$$= 1 : 17\frac{1}{4} \times \frac{50}{400} \text{ or } 1 : 2.16, \text{ and } 1 : 11\frac{5}{8} \times \frac{50}{400} \text{ or } 1 : 1.48.$$

And the ratios of  $G : P$  will evidently be obtained by deducting a unit from each of the foregoing, or

$$\begin{array}{l} \text{When } G : G + P = \overset{\text{System A.}}{1 : 2.16} \text{ and } \overset{\text{System B.}}{1 : 1.48} \\ \text{Then } G : P = 1 : 1.16 \text{ and } 1 : 0.48 \end{array}$$

Now for the span of 400 feet let us assume the value of  $P$  to be = 600 tons; and we consequently have

$$G = \begin{cases} \overset{\text{System A.}}{= \frac{P}{1.16}} & \text{and} & \overset{\text{System B.}}{= \frac{P}{0.48}} \\ = \frac{600}{1.16} = 518 \text{ tons, and } \frac{600}{0.48} = 1250 \text{ tons.} \end{cases}$$

So that instead of the weights of the girders being as before in the proportion of  $1 : 1.5$  for the 50 feet span, they are for the 400 feet span in the proportion of  $1 : 2.4$ , although the relative economic merits of the systems A and B remain the same as before.

The economic merit of each system may be represented by the relative value of the ratio  $\frac{S(G + P)}{G}$ ; for the two systems A and B, the

values of this are as  $1.46 : 1$ , and on decreasing the spans of the girders the proportion of their weights to one another would assume more and more nearly this value taken inversely.

For a span of 500 feet, the ratios of  $G : G + P$  become  
 $= 1 : 17\frac{1}{4} \times \frac{50}{500}$  and  $1 : 11\frac{5}{8} \times \frac{50}{500}$  or  $1 : 1.725$  and  $1 : 1.183$ , and



consequently the ratios of  $G : P$  become  $= 1 : 0.725$  and  $1 : 0.183$ ; and if we assume  $P = 800$  tons,

$G$  will become  $= \frac{800}{0.725} = 1103$  tons, for the A system,

and  $G$  "  $= \frac{800}{0.183} = 4371$  tons, for the B system;

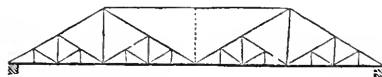
or in the proportion nearly of  $1 : 4$ . We consequently have the following results:—

	System A.	System B.
Ratio of the economic merits taken inversely	$= 1$	$= 1.46$
Ratio of the weights of the girders:		
when the span is 50 feet	$= 1$	$= 1.5$
" 400 "	$= 1$	$= 2.4$
" 500 "	$= 1$	$= 4$

From the above, as from Table IV., page 84, it will at once be seen that if—from adopting a more economic design, or employing a stronger material—we can reduce the weight of a girder, taken in proportion to the load it can carry, even by what in the case of a small structure might at first sight be thought an insignificant amount, yet when a case occurs requiring a girder so great that its own weight constitutes an important portion of its load, the saving of material from that slight improvement may become immense. It is therefore an imperative duty of the engineer entrusted with the establishment of any very large structure of this class—who would not do injustice to those whose capital is embarked in the undertaking, nor bring discredit on the engineering character of his country—to search out the most economic systems of construction, and by a careful investigation, founded on the principles we have already indicated, to ascertain what materials it is best in the circumstances to employ.

*Bowstring and other Girders.*—There are various excellent forms of girders for which it is desirable that the values of  $k$  should be determined; of these we may mention the bowstring girders (see page 35), and the original design, fig. 1. We may return, on some future occasion, to the consideration of these. There is little doubt, however, that the bowstring girder, when made of sufficient depth, and also the design, fig. 1, have great economic merits. But when such forms as

Fig. 1.



these, and No. 9 of page 164,\* are made use of under the ordinary arrangements, a great deal of material must be added to the upper members towards their extremities to give the necessary lateral stability, since the introduction of horizontal or transverse bracings at these parts is prevented by the position of the roadway. By modifying the arrangements, however, we may obviate this objection. Our first pro-

\* Jour. Frank. Ins., vol. xlv. page 237.

posal for this purpose is, that for a double line of railway the bridge should be composed of four single girders, the two central ones being placed a considerable distance apart, as in fig. 2, this gives space for the application of continuous horizontal and transverse bracings; at the same time the amount of material  $E$ , to be added to resist the longitudinal stresses induced by the wind, is diminished on account of the increased width given to the structure; and further, the length of bearing of the transverse girders becomes reduced to a minimum.

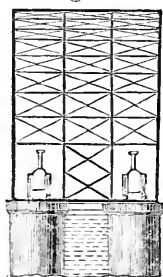
Another arrangement, which we propose as possessing some advantages, is shown in section, fig. 3.

*Girder Bridges Compared with other Systems, for Great Spans.*—We have treated of that branch only of the general subject of *great spans* which comes under the heading of *girder* construction, or wherein the pressures upon the supports are vertical. We do not at present purpose entering upon the other branches, which include suspension bridges and untied arched structures; but much of what we have said regarding girder bridges, and the principles of calculation we have exhibited, are equally or with slight modifications applicable to these other systems of construction; thus, for instance, formulæ 1, 2, and 3, page 21, are of universal application.

We believe that the economic advantages to be derived from the employment of the so-called *rigid* suspension bridges and untied arches, as compared with properly constructed girder bridges, have been very much over-estimated: this must chiefly result from very faulty examples of girders having been chosen in drawing the comparisons.

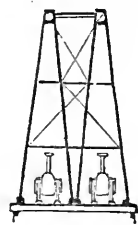
When girders such as we have pointed out are adopted, and superior materials made use of, a very low value may be assigned to  $k_{3.5}$ . We shall, for the sake of example, suppose this value to be  $= .0007$ , although we have no doubt that one still lower could readily be reached by the adoption of the arrangements in figs. 1, 2, or 3, or with bow-string or other girders. The values of the parts composing  $F$  may also

Fig. 2.



End view.

Fig. 3.



Transverse section.

be considerably reduced below what are shown in Table II., page 76, on account of increased width of structure, shorter bearings for the transverse girders, and the use of steel for the ties; and for extreme spans the movable loading may be taken at less than one ton per foot

run. Under these assumptions a span of 800 feet, and that in a non-continuous structure, would be of easy accomplishment; thus, let us take—

*For a Girder Spanning 800 feet.*

E	.	.	=	120 tons.
H and T bracings	.	.	=	80
Platform, &c.	.	.	=	200
F	.	.	=	400
$w_2$	.	.	=	600
$F + w_2$	.	.	=	1000 tons.

And by formula (3) we have

$$g = \frac{k s (w_2 + F)}{1 - k s} = \frac{\cdot 56}{\cdot 44} 1000 = 1273 \text{ tons.}$$

$g + E$ , or girders complete	.	=	1393 tons.
$g + F$ , or half of complete bridge for a double line of railway	} .	=	1673 "

It should be borne in mind that this result, although so very satisfactory on the score of lightness, is obtained with the factor of safety taken so high as 3·5; for such spans a lower rate of strength would be sufficient according to some authorities. We venture then to think that the girder system, when its combined advantages of rigidity and facility of erection are taken into account, will contrast favorably in a general point of view with any other system of construction, even for such spans as 700 or 800 feet. Its rigidity gives it a favorable distinction from the suspension system; while its facility of erection will in most situations prove an advantage over the arch.

The suspension bridge if thoroughly braced, and when the cost of the *land chains* and that of the heightened towers are included, will not probably be much, if any, cheaper than the best girder one, especially if, as would probably be the case, a higher factor of safety were insisted upon for the former than for the latter. In some situations indeed, as when an unnavigable torrent of great width has to be crossed, the suspension principle is the only feasible one.

The untied arch must ever have a great excess of sectional area, or a large addition of material to stiffen and brace it, which will greatly reduce its economic merit; a centring being required for its erection, will also in many situations prove almost a barrier to its use.

If it be desired, instead of employing a general factor of safety = 3·5 as in the above calculation, to have a higher factor (say = 4·5) for the movable portion of the loading, and the ordinary value = 3 for the fixed loading; all we have to do is to substitute for  $w_2$  the

value of  $\frac{4\cdot 5}{3\cdot 0} w_2$ , and make use of 3 as the *general factor*, and instead

of  $k_{3\cdot 5} = \cdot 0007$  to employ  $k_3 = \cdot 0006$ : thus,

$$g = \frac{\cdot 0006 \times 800}{1 - \cdot 0006 \times 800} F + \frac{4\cdot 5}{3\cdot 0} w_2 = \frac{\cdot 48}{\cdot 52} 1300 = 1200 \text{ tons.}$$

G + E, or girders complete	}	= 1320 tons.
G + F, or half of complete bridge for		= 1600 "
a double line of railway		

The results being somewhat less than when the general factor 3.5 is used.

*Approximate Comparison of the Weights of Plate and Open-work Girders for Various Proportions of Depth to Span.*—Whether the web of a girder be made of plate-work or open-work, the sum of the weights of the top and bottom may be set down as the same.\*

Now we found that when  $s \div d = 8$ , the weight of the bracing of an open-work girder was equal to half the weight of the booms; and that its weight was nearly constant, although the depth of the girder underwent considerable changes. Other things equal, we may take the weight of the booms in both systems as inversely proportional to the depth, or as  $s \div d$ .

In the plate system, we believe, we do not overstate the case when we assume that the weight of the sides will vary nearly in proportion with the depth of the girder; this takes for granted that any saving that can be secured from thinning the plates of the sides when the depth is increased, will be fully absorbed in necessary additions to the sections of the L and T irons to give the requisite lateral stability and stiffness.

In the Conway tube the weight of the sides is equal to half that of the booms, and we have shown that  $s \div d$  is fully equal to 18, but as we do not wish to be chargeable even with not favoring the plate form, we will call this = 16. From these data, and taking the value of  $s \div d$  to represent the weight of the booms, we at once obtain the results in the following table:—

Proportion of Span to Depth, or $s \div d$ .	Total and partial Weights of the Girders, when the same load is supported.					
	Open-work Girder.			Plate-work Girder.		
	Booms.	Web.	Total.	Booms.	Web.	Total.
32	32	+	4 = 36	32	+	4 = 36
28	28		4 = 32	28		4.57 = 32.57
24	24		4 = 28	24		5.33 = 29.33
20	20		4 = 24	20		6.4 = 26.4
16	16		4 = 20	16		8 = 24.0
12	12		4 = 16	12		10.67 = 22.67
8	8		4 = 12	8		16 = 24
4	4		4 = 8	4		32 = 36

\* This ignores the moments of the longitudinal stresses of the plates of the web; against these may be placed the fact that the lower boom of an open-work girder may be made stronger for its weight than the corresponding boom of a plate girder. Where, however, the depth is great in proportion to the span, these moments may become of such importance as to require account being kept of them; the effect being to reduce somewhat the weight of metal in the booms of such girders. The late Mr. Robert Stephenson seems to admit that in ordinary cases at least, these moments should not be counted upon, as we find at page 597, article "Iron Bridges," in the 8th edition of the "Encyclopædia Britannica," these words: "The central strain on the top and bottom flanges, which depends solely on the depth of the girder, and is perfectly independent of the system which connects them. . . . ."

This table, although professedly only a rough approximation, offers many interesting points of comparison, several of which give us confidence in its contents not being very far from accurate.

We may take the weights given in larger type as practically correct. Those for the webs of the shallower girders of the open-work character are probably overstated, so that it is for the last example only that any economic exaggeration can exist. In the plate girders there may be room for more doubt, but the fact of the minimum weight for these pointing to the proportion of 1:12 as the most economical for that of the depth to the span is important, since if we are wrong in our views regarding the increase in the weight of the web—and it should really not increase in weight so rapidly as the depth—then the girder of minimum weight would result from a still higher proportioned depth than one-twelfth, which would stultify the practice of the advocates of this mode of construction. One-twelfth of the span is the greatest depth for large plate girders that would probably be attempted. There may, however, arise subordinate questions here,—viz: that the economic laws governing the ratios of span to depth (for plate girders especially) may not be constant for different spans, and that for a short girder a higher value of the depth may be resorted to. Various reasons could be adduced in support of this, besides that of every-day practice.

We may further notice that in the above table the girders become equally economic when the depth is made equal to the span divided by 32, or about half the proportional depth of the Conway. For depths less than this the economic merit would be on the side of the plate system; this value, 32, is that of the  $x$  contained in the article at page 236 of vol. xvii, of this Journal.

R. H. B.

Edinburgh.

### *International Exhibition.*

From the *Mechanic's Magazine*, December, 1862.

#### CLASS X, SECTION A—JURORS' REPORT.

##### JURY.

A. Bommart, France; General Inspector in the Imperial Corps of Bridges and Roads.

J. Kelk, London; Contractor.

Koch, Zollverein; Government and Architectural Councillor, Berlin.

J. Leclerc, Belgium; Inspector of Agriculture and Engineer of Bridges and Roads:

Maurice Loehr, Austria; Imperial Councillor of the Board of Trade and Public Works.

C. Manby, F. R. S., London; Hon. Sec. to the Institute of Civil Engineers.

Thomas Page, London; Civil Engineer.

Sir J. Rennie, F. R. S., F. G. S., President of Section, London; Civil Engineer.

Marquis of Salisbury, K. G., Chairman, London.

Cesare Valerio, Italy; Member of the Italian Parliament.

##### ASSOCIATES.

Baron Baude, France; Engineer to the Imperial Corps of Bridges and Roads.

Mille, France; Engineer-in-Chief of Bridges and Roads.

I. *Bridges.*—There are few more important and difficult operations in civil engineering than the construction of bridges across great rivers, estuaries, and valleys, and none which require greater skill and

judgment in design and construction, in order that the works may be properly adapted to fulfil the object in view in the best manner and at the least possible cost; and, it is but justice to say, that amongst the numerous objects of this class submitted to our examination, there are works of the highest merit, and which have been most successfully carried into effect.

Amongst the most prominent and important of this kind may be mentioned the class of wrought-iron tubular girder bridges exemplified by the remarkable and extensive bridge erected across the river St. Lawrence, at Montreal, for the Grand Trunk Railway in Canada. This bridge was based upon the system introduced in the "Conway" and "Britannia" bridges, on the Chester and Holyhead line of railway.

All these three bridges were designed by and constructed under the direction of the late Robert Stephenson, M. P., F. R. S., and both he and the resident engineers and contractors are entitled to the greatest possible credit for the novelty, originality, and boldness of the designs, the admirable and ingenious contrivances employed in the structures as they have been carried into effect, as also for the very complete manner in which they have answered the objects for which they were designed and constructed, so as to offer the least possible obstruction to the navigation, and at the same time to afford the greatest and most substantial accommodation to the traffic passing over them. They were necessarily attended with great practical difficulties in the execution, not only in combining and putting together the vast masses of wrought iron, rarely before attempted upon such a great scale, but also in the planning and construction of the foundation and the masonry piers, particularly in those of the "Victoria" bridge, across the St. Lawrence, where special provision was necessary for resisting the pressure of the immense masses of floating ice set in motion on the breaking up of the frost at each spring. For the foundation of these piers and ice-breakers, Mr. Hodges, the engineer of the contractors, devised a most ingenious system of movable coffer-dams, which answered admirably, and to him, as to Sir Morton Peto, M. P., Mr. Brassey, and Mr. E. L. Betts, the enterprising contractors for the works, the utmost credit is due for the successful manner in which the great difficulties were met and overcome, and for the general successful result of their work. It is not necessary to describe these great works in detail, as this has already been done in the masterly and elaborate description of the Conway and Britannia bridges by Mr. Edwin Clark, and Messrs. Peto and Betts, and Mr. Hodges in the description of the "Victoria" bridge; to which works, those who take an especial interest in these important subjects are more particularly referred.

To Mr. G. R. Stephenson, as the representative of his cousin, the late Mr. Robert Stephenson, M. P., F. R. S., has been awarded a medal for the extraordinary boldness of conception and the great ingenuity of the construction; and to Sir S. Morton Peto, Bart., M. P., Mr. T. Brassey, Mr. E. L. Betts, and Mr. J. Hodges, a collective honorable mention, for the successful execution of this bridge, and for

the ingenuity displayed by Mr. Hodges in the construction of the coffer-dams.

Next, and scarcely inferior in importance to the above mentioned bridges, may be mentioned the bridge across the Wye, at Chepstow, and the "Albert" bridge over the Tamar, at Saltash, both designed by, and constructed under the direction of, the late Isambard Kingdom Brunel. These are of a somewhat different character, being a combination of a wrought iron superstructure with cast iron columns, the arrangement being upon the insistent and the suspension principles combined.

It may be a question whether one of these systems, particularly the insistent principle alone, if properly applied, of the requisite dimensions, would not have been as efficient, simpler, and better calculated to have answered the object in view : nevertheless, these two bridges have been extremely well designed and constructed, and they practically fulfil their object most successfully. The foundation of the great central, or deep-water pier, in the Tamar, for the Saltash bridge, was a most difficult and hazardous undertaking, as it was necessary to carry it down through a depth of water of 82 feet at high water, with a rise of 18 feet of tide. This foundation was carried down through a bed of soft mud, nearly 16 feet thick, to the solid rock, which was effected by means of a wrought-iron cylinder of 37 feet diameter and 90 feet in height, which was forced down to the bottom partly by insistent weight, and partly by means of atmospheric pressure. The proceedings were so well arranged that little hazard was incurred, and the works of sinking the cylinder, constructing the masonry foundation, erecting the iron columns upon it, and lifting the tubes, were most successfully accomplished. In connexion with the execution of this work, Mr. Brereton, the chief assistant of Mr. Brunel, should be mentioned as having carried out the views of the engineer most efficiently. To Mr. Isambard Brunel, as the representative of his father, the late Mr. I. K. Brunel, F. R. S. (United Kingdom, 2245), has been awarded a medal, for the boldness of design and for ingenuity and goodness of construction, and for the novel and excellent method of sinking the foundations of both these bridges.

The next work of this class is the lattice bridge across the river Boyne, at Drogheda, on the line of the Dublin and Belfast Railway. It was designed by and constructed under the directions of Sir John Macneill. It is upon the lattice principle of wrought iron, and is by far the largest structure of the kind which has hitherto been erected in the United Kingdom. The invention, or rather the first great application of this class of bridge, may be said to have taken its origin in the United States of America, where such structures of timber have been employed to a great extent. The merit of their introduction into Great Britain in the form of wrought iron may be attributed to Sir John Macneill, and they are now largely employed on the Continent, and indeed all over the world. They come under the class of girder bridges, and their chief merit may be said to consist in their lightness and economy, consistent with a proper degree of strength. The bridge

over the Boyne, above mentioned, as well as another upon the same principle across one of the public streets at Dublin, upon the same line of railway, are extremely well designed and constructed, and are excellent examples of the kind, and as such are entitled to a considerable degree of credit.

To Sir J. Macneill, F. R. S. (United Kingdom, 2316), has been awarded a medal for the importance of the design and the successful execution of this bridge; in which he received very efficient co-operation from James Barton, resident engineer.

Several large bridges upon the same principle have been designed by, and constructed for, Lieut. Col. Kennedy, upon the line of the Bombay and Baroda Railway, India. The piers of these bridges are formed by means of Mitchell's cast iron screw piles, firmly fixed in the bed of the river, and properly braced together by wrought iron ties. These structures have not any pretensions to originality, but they are remarkable for the simplicity and economy of their construction, for their successful completion, and for their completely answering the object for which they are intended. To Lieut. Col. Kennedy (United Kingdom, 2307) has been awarded a medal for the extensive application of screw-piles to bridges in India.

To Messrs. Gilkes, Wilson, and Co. (United Kingdom, 2290), has also been awarded a medal for the excellence of execution of the iron railway viaduct, with cast iron diagonally braced piers, erected by them over the river Belah, from the designs and under the direction of Mr. Bouch.

In connexion with this branch of engineering, a medal has been awarded to Mr. E. C. E. Dapples, of Lausanne (Switzerland, 127), for an ingenious modification of the screw-pile shoes for timber or iron piles.

Next must be mentioned the bridges, models of which are exhibited (under the No. 1251, in the French Catalogue) by the Minister of Agriculture, Commerce, and Public Works of France, whose liberality in collecting and transmitting to this country so excellent a collection of models of interesting works cannot be too highly eulogized. Many of these bridges are remarkable for the ingenuity and boldness of their design, and for the very successful manner in which they have been carried into effect.

First amongst these may be mentioned the great Turning Balanced Bridge across the Penfeld, a creek connected with the naval arsenal of Brest; this structure is by far the largest of the kind that has ever been attempted, and as such requires particular notice. It is composed wholly of wrought iron, with the exception of the counter-balance weights, which are of cast iron. The total width of the opening, or clear space between the two circular piers, or abutments on the opposite shores, is 106 metres. The bridge itself consists of two equal portions, which meet in the centre, at an elevation of  $19\frac{1}{2}$  metres above the level of high tide, each being supported on either side by a massive circular tower of granite masonry, upon which they revolve on a series of cast iron rollers, in a massive iron frame, which



is made to rotate by means of a system of wheel-work, worked from the top by two men for each half, by whom, in calm weather, the operation of opening and shutting the bridge is performed in about fifteen minutes.

When the bridge is closed it is fixed in its place by means of self-acting keys, which are easily detached when it is required to open it for the passage of full sized vessels.

The total width of the roadway, including that for the carriages as well as for the foot passengers, is  $7\frac{1}{2}$  metres.

The ends between the piers and the abutments, at the adjoining streets, are filled with the counter-balance weights, which are so regulated as to balance the other two and longer portions, between the piers and the centre or the opening, so perfectly as to enable the rotation to be effected with the least possible friction; and in order to afford ready access for repairs to the rollers, arrangements are made for lifting the entire ring, by hydraulic pressure, within a few minutes.

This bridge may be said to fulfil its purpose admirably, and whilst it forms a convenient and much required communication between the towns of Brest and Récouvrance, which are situated on either side, it affords free passage for vessels of war under and through it, in consequence of its great height from the surface of high-water to the under side of the arch.

The original project for this great work is due to Messrs. Cadiat and Oudry, to whom a collective medal has been awarded as the authors of the original project, and for its boldness and unique character; but the actual structure was designed and constructed by M. Mathieu, the able engineer of the Creusot Iron Works, and by Messrs. Schneider and Co., who were the contractors for the work. The erection of the structure was superintended by Messrs. Matrot de Varennes and Aumaitre, engineers-in-chief of bridges and roads, and M. Rousseau, engineer.\*

The next bridge most worthy of remark is that erected over the valley of the Sarine, on the line of the Fribourg and Lausanne Railway. It was designed and constructed by M. Mathieu, the engineer for the Creusot Company, who were the contractors for the work, and at whose establishment it was all manufactured.

The total length of this bridge is nearly 329 metres, and it consists of seven openings, of nearly 49 metres each, supported upon 6 cast iron piers, composed of diagonal-framed panels, firmly braced together by wrought iron rods placed diagonally. The openings are spanned by wrought iron girders, upon the trellis principle; the highest pier in the deepest part of the valley being 80 metres in height, of which the upper length of 44 metres is in metal, so that in point of economy it became an object of the greatest importance to avoid the construction of scaffolding, which would have been attended with considerable expense; this was happily effected by a very ingenious and novel system.

\*It would have been proposed to award a medal to M. Mathieu for this important work, but it was reserved for the design and execution of the Bridge of Fribourg, which are scarcely, if at all, less ingenious and successful than those of the Bridge of Brest.

The lattice girders, with the platform forming the whole width of the bridge, were, in the first instance, constructed; or put together on one of the adjoining abutments, and placed upon rollers, over which they were drawn forward until the end overhung the position at the first pier, having sufficient counterbalancing weights at the ends to prevent them from falling as they were moved onward. As a further precaution against this danger, the ends were stayed by chains and rods of wrought iron, attached to strong derricks, or cranes fixed upon the piers, provided with proper machinery for hauling them along, so that in proportion as they advanced the chains were shortened, until the ends of the girders reached the point over each pier. The panels for forming the pier were then brought forward upon the girders and platform, and were lowered to their position; so that the structure, in fact, grew up beneath the girders, which were then again drawn forward over the piers, and the same process was repeated until the whole bridge had been drawn across, when the platform was securely fixed in its position. By means of this novel, simple, and ingenious contrivance, this bold and economical railway bridge, or viaduct, was most successfully constructed, to the great credit of the Creusot Iron Company and their able engineer-in-chief, M. Mathieu, inventor of the method of construction and builder of the bridge, to whom the jury have awarded a medal, with the expression of their highest satisfaction for the invention and successful application of the method employed in the construction; and they thought it right to give an honorable mention to M. Clerc, for the excellence of the model of the bridge, exhibiting the mode of construction.

A road bridge, called the "Pont de St. Just," across the mountain torrent, the Ardeche, upon the same principle, with stone piers, was designed originally by M. Oudry, and constructed by the Creusot Iron Company, under the immediate direction of M. Mathieu, with equal success. This bridge, which consists of six spans of 46.26 metres each, was also remarkable for the obstacles encountered, not only in constructing the piers, in consequence of the extreme violence of the torrent during floods, but because it was absolutely necessary to provide a means of placing the wrought iron arched girders, without having recourse to the ordinary mode of fixing scaffolding beneath. This was accomplished by having a counterbalanced scaffolding, which was propelled forward from the abutment over the piers consecutively, having on it the means of raising the arched iron girders to their places on the piers. This was very successfully accomplished, without accident; and the award of a medal would be justly due to M. Mathieu, the engineer-in-chief of the Creusot works, to whom were entrusted all the details of the construction of this work, if he had not gained one for the bridge of Fribourg.

The next viaduct bridge worthy of remark is that over the Rhine, at Kehl, for connecting the Eastern Railway of France with the German system of railways at Strasbourg.

The execution of this great work was, by mutual consent, apportioned between the engineers of the Eastern Railway, who undertook

the construction of the foundations and the piers, and the engineers of the Grand Duchy of Baden, who were charged with the execution and fixing of the superstructure. The foundations and the mode of executing them were designed and executed by M. Vuigner, engineer-in-chief, and Monsieur Fleur-Saint-Denis, resident engineer, with M. de Sappel, acting engineer; and their designs were carried into effect with great intelligence by the enterprising contractors, Messrs. Castor.

The general features of this viaduct are, masonry piers, supporting a superstructure of wrought iron girders, on the trellis principle, with a lifting, opening at each extremity, to permit the passage of the masted vessels which navigate the Rhine.

The principle difficulties in the construction of this bridge arose from the depth of the river, the rapidity of the current, and the shifting nature of the bed, which, being composed of loose gravel, was at times scoured away to the depth of many feet; so that no bridge could be rendered permanent, unless the foundations of the piers were carried down to a depth below the action of the current. In order to effect this it was necessary to resort to extraordinary measures. This was effected by the employment of large wrought iron caissons, placed side by side, so as to cover the entire space of the pier. These contained air cylinders, with valves in them rising from the top of the caissons to above the level of the water, and a large cylinder, open at both ends, having its lower extremity descending below the edges of the caisson. Within this latter cylinder was fixed a dredging frame and buckets.

(To be Continued.)

### Prime Movers.

From the London Artizan, December, 1862.

The unit of work is one horse power, or 33,000 lbs., raised one foot per minute.

Let  $P$  represent the actual pressure of steam per square inch on the piston,  $p$  the resistance per square inch, caused by the exhaust steam on the opposite side of the piston, both in pounds,  $N$  the number of strokes per minute, and  $l$  the length of the stroke in feet, and  $a$  the area of the piston; then, if we represent the actual horse power by  $H a$ ,

$$H a = \frac{(P - p) a \cdot l \cdot N}{33000} \text{ which is the work done upon the piston.}$$

To ascertain the mean pressure upon the piston, indicators are connected with the top and bottom of the cylinder, which register the pressure at every part of the stroke, from which register the mean pressure may be found; the diagram drawn by the indicator is also valuable as showing accurately the action of the slides.

The nominal horse power of an engine is usually far less than the actual horse power, being determined by a measurement of the cylinder without regard to the pressure at which it is intended to be worked, although a pressure is determined upon which the formula depends,

thus for condensing engines the value of  $(P - p)$  is very generally taken at 7 lbs.

The nominal horse power provides the data by means of which engines may be compared as to commercial value, the price being usually fixed at per horse power.

The following are some of the formulæ used for determining the nominal horse power of engines,—

$a$  = area of piston in square inches.

$d$  = diameter of piston in inches.

$H n$  = nominal horse power.

#### *Condensing Engines.*

Watt's Rule.  $H n = \sqrt[3]{\text{stroke} \times d^2}$

Manchester Rule.  $H n = \frac{a}{2\frac{2}{3}}$

Leeds Rule.  $H n = \frac{d^2}{30}$

#### *Non-Condensing Engines.*

Manchester Rule.  $H n = \frac{a}{10}$

Leeds Rule.  $H n = \frac{d^2}{16}$

The power of steam boilers may be safely calculated at one horse power for every square yard of heating surface and square foot of fire surface, this being sufficient to evaporate one cubic foot of water per hour. For cylindrical boilers, with the fire underneath, the horse power is equal to one-fifth the horizontal section; or if

$l$  = length in feet,

$d$  = diameter in feet,

$$H = \frac{d l}{5}.$$

If there are flue tubes as well, their section must be added to that of the boiler.

The efficiency of vertical heating surface is only half that of horizontal surface above the fire.

With regard to the capacity of boilers, 27 cubic feet per horse power is economical.

The Lancashire rule allows one cubic foot of boiler room for every square inch of piston.

The North Country rule allows a cubic foot of boiler room for every circular inch of piston.

Water Wheels.

Let  $Q$  = the quantity of water supplied per second, in cubic feet.

$w$  = the weight of a cubic foot.

$v$  = the supply velocity, in feet per second.

$v$  = the discharge velocity, in feet per second.

$h$  = the difference of head of water before and after its action on the wheel, in feet.

$N$  = the number of pounds raised one foot per second.

The total energy of the water is,

$$N = Q w \left\{ h + \frac{v^2}{2g} \right\}$$

the energy of the water when discharged,

$$N = Q w \frac{v^2}{2g}$$

the power impressed upon the wheel,

$$N = Q w \left\{ h + \frac{v^2 - v^2}{2g} \right\}$$

$$h + \frac{v^2}{2g}$$

represents the theoretic head which we will call  $h_1$ ,

The limit to the efficiency of the machine is evidently,

$$Q w \left\{ h + \frac{v^2}{2g} \right\}$$

but it is usually far removed from this.

We will represent the co-efficient for reducing the total power of the water to the available power by  $c$ ; then calling  $H$  the horse power of the machine,  $H = 0.1227 . c . Q h$ .

The usual velocity of overshot and breast wheels is from three to six feet per second.

Turbines are usually of small diameter; they work under great heads; one erected at St. Blasien working under a fall of 354 feet, producing 0.75 of the power expended upon it, it would make 2300 revolutions per minute. Turbines seldom have a velocity less than one-half or one-third of that due to the fall.

The values of  $c$  for the various forms of water wheel are as under—

Breast wheels,	}	.	.	.	0.75 to 0.85
Overshot wheels					
Undershot wheels, radial floats,	.	.	.	.	0.30.
Undershot wheels, curved floats,	.	.	.	.	0.60
Turbines,	.	.	.	.	0.70 to 0.90

*Iron Pipes for Railway Bridges in Alluvial Districts.*

From the Lond. Civ. Eng. and Arch. Journal, Sept., 1862.

Conspicuous among the British Engineering Models at the International Exhibition may be observed Colonel J. P. Kennedy's models and drawings (2307, Class 10), illustrating "the Finance of Railways and other public works." Of these the most copious and important subject relates to the construction and erection of iron piers and superstructures for railway and other bridges and viaducts in alluvial districts. The results are derived from the system which he has adopted on the Bombay and Baroda Railway. That system has been already noticed in this Journal (vol. xxiv., p. 251), to which we beg to refer our readers. It is well adapted to the requirements of the colonies, in consequence of its economy in first cost, facility of transit in long voyages and of erection in situations where the supply of skilled labor and mechanical appliances are very limited.

The practice held forth is based upon the erection of 95 bridges across rapid rivers, most of them tidal, and flowing upon alluvial beds; the aggregate length of bridge-work being about  $6\frac{3}{4}$  miles. The length of line conceded for construction was 313 miles, of which about two-thirds are finished, and the balance is on the eve of completion. The financial powers of this line may be estimated from the unprecedented fact that single engines, four wheels coupled, have hauled along its entire length, and in each direction, trains of 72 carriages, conveying 4000 passengers at the regulated speed of 20 miles an hour. Colonel Kennedy, from the outset of his operations, has aimed at securing low fares for his passengers, with high dividends for his shareholders. He expects that the cost of the line shall not exceed £11,000 per mile, notwithstanding its difficult character and the antagonism with which he has had to deal.

The extent of country to be supplied by railways in India is very great, averaging 1000 miles across from west to east, and more than double that distance from north to south. It is intersected by two principal ranges of mountains; the Vindea central range running from west to east, and the Syhadree range, 2000 feet high, running from the centre of India southwards along the west coast, with a steep declivity towards the sea on the western side, but a gradual fall inland on the eastern. In the case of the Bombay and Baroda line great care was necessary in surveying the country beforehand, to make sure that all branch lines intended to be constructed afterwards would be practicable, and 4000 miles of ground were examined before any steps were taken in commencing the works: this was the more important in so mountainous a country, in order to get the best possible levels along the entire course of the line, and the result was a ruling gradient of 1 in 500. The population of the country and its capabilities of supplying produce are so great as to ensure an enormous traffic for all the railways, and financial difficulties alone have hitherto retarded the progress of railways. The vast importance of ready communication through India may be judged of from the fact that India already consumes a larger amount of British produce than any other country;

hence it is that, while her colonies are the main support of the industrial classes at home, England must look to her colonies and to India especially for the maintenance and advancement of that industry; and facility of road traffic is therefore essential for increasing the demand for home productions and for returning larger supplies of raw material.

From the nature of the country it frequently occurs in India that the practicability of building a bridge in a particular locality is the consideration which determines whether there should be a road or not; and the same condition decides the question also as to a railway. The large majority of the lines have to follow the valleys and to cross the rivers frequently, requiring a special construction of bridge piers for the alluvial soil, where solid masonry piers are most costly if not impracticable. The piers are thus of vital importance: many kinds of superstructure may be adopted, but on the piers depend the practicability of making the railway. On the Indian lines miles of bridges have to be dealt with, which must be strong enough to withstand the fierce monsoon floods running at 6 to 10 miles per hour. Hence great strength and durability are necessary in bridge piers, combined with cheapness of construction; otherwise a railway could not be attempted with any prospect of a successful issue.

The piers are composed of hollow cylindrical cast iron piles, of 1 inch thickness of metal and 2 ft. 6 ins. outside diameter, cast in 9 feet lengths, weighing about  $1\frac{1}{2}$  tons each; these are of two principal patterns, for the portions of the piles above and below the ground. That above the ground, has flanches outside for bolting the lengths together by twelve 1-inch bolts; while that underground has the flanches inside bolted together by ten 1-inch bolts, and is flush on the outside so as to offer no resistance in penetrating the ground; they are large enough inside to leave room for a man getting in to bolt the several lengths together properly in the process of erecting. The foundation is obtained by one of Mitchell's screws at the bottom of each pile, of 4 ft. 6 ins. diameter, which finds its own foundation without the expense of coffer-dams or any other artificial preparation of the ground. The upright piles are placed 14 feet apart from centre to centre, and are sunk to a depth of about 20 feet in the ground; but where the ground is softer than usual they are carried down deeper, to obtain the requisite strength of foundation. The greatest length of pile used has been 45 feet below the ground and 72 feet above. The oblique piles forming the struts are inclined at an angle of about  $30^{\circ}$  to the upright piles; they are precisely the same in construction as the upright piles, and are joined to the latter at about the ordinary flood level by a cap cast at the proper angle, which clips the body of the upright pile. The piles are all connected together above ground by horizontal and diagonal wrought iron bracing, attached to lugs cast on the piles by a pin at one end and a gib and cotter at the other. The several parts of the bracing act alternately as struts and ties according to the direction of the current, and in consequence of this alternate strain an accurate fit of the bracing is required; to insure this the joints at one end of each are therefore left to be done in India from measurement on the

site, this being the only forging required in India. A party of submarine fitters is employed for attaching the bracings to the pilings and other work under water. These men are furnished with Heinke's helmets and dresses. The outside piles are faced with a double row of timber as a fender to protect them against shocks from anything floating in the water and brought down by the current. The weight of a single complete pier of five piles for two lines of rails, 63 feet high from the foundations, is  $75\frac{1}{2}$  tons, and the cost £624, delivered in London.

This form of girder, when manufactured and accurately fitted in England, requires the smallest amount of skilled labor for its erection abroad on reaching its destination; only a few pins and bolts have to be put in for completing the girders, and the skilled labor required for riveting box girders or lattice girders is avoided.

(To be Continued.)

### *On the Strength of Long Pillars.* By B. B. STONEY, B. A.

From the Lond. Pract. Mechanic's Jour., Dec. 1862.

[Read before the Royal Irish Academy, June 23, 1862.]

Among the numerous difficulties encountered in designing large iron structures, such as railway girders or roofs of large span, none perhaps is of more importance, or requires greater skill to overcome, than the tendency of parts under compression to deflect beneath the pressure, and yield sideways, like a thin walking-cane, when the load is greater than it can support without bending.

To understand the matter clearly, we must recollect that the mode in which a pillar fails varies greatly, according as it is long or short in proportion to the diameter. A very short pillar—a cube, for instance—will bear a weight sufficient to splinter or crush it into powder; while a still shorter pillar—such as a penny, or other thin plate of metal—will bear an enormous weight, far exceeding that which the cube will sustain, the interior of the thin plate being prevented from escaping from beneath the pressure by the surrounding particles. We can thus conceive how stone or other materials in the centre of the globe withstand pressures that would crush them into powder at the surface, merely because there is no room for the particles to escape from the surrounding pressure.

It has been found by experiment that the strength of short pillars of any given material, all having the same diameter, does not vary much, provided the length of the pillar is not less than one, and does not exceed four or five diameters; and the weight which will just crush a short pillar, one square inch in section, and whose length is not less than one or greater than five inches, is called the *crushing strength* of the material experimented upon. If the length of pillars never exceeded four or five diameters, all we need do to arrive at the strength of any given pillar would be to multiply its transverse area in square inches by the tabulated crushing strength of that particular material. It rarely happens, however, that pillars are so short in proportion to their width; and hence we must seek some other rule for calculating their strength, when they fail, not by actual crushing, but by flexure.



If we could insure the line of thrust always coinciding with the axis of the pillar, then the amount of material required to resist crushing merely would suffice, whatever might be the ratio of length to diameter. But practically it is impossible to command this, and a slight deviation in the direction of the thrust produces a corresponding tendency in the pillar to bend. With tension-rods, on the contrary, the greater the strain, the more closely will the rod assume a straight line, and, in designing their cross section, it is only necessary to allow so much material as will resist the tensile strain. This tendency to bend renders it necessary to construct long pillars, not merely with sufficient material to resist crushing, supposing them to fail from that alone, but also with such additional material or bracing as may effectually preserve them from yielding by flexure. It is evidently, therefore, of considerable importance that we should ascertain the laws determining the flexure of long pillars, which may be done as follows:—

Let the figure represent a pillar, very long in proportion to its breadth, and just on the point of breaking from flexure.

Let  $w$  = the deflecting weight ;

$b$  = the breadth of pillar ;

$d =$  its depth ;

$l =$  its length ;

$h$  = the central deflection ;

$R$  = the radius of curvature :

$c$  = the resultant of all the longitudinal forces  
of compression on the concave side at  
the centre of the pillar ;

$\tau$  = the resultant of all the longitudinal forces  
of tension on the convex side;

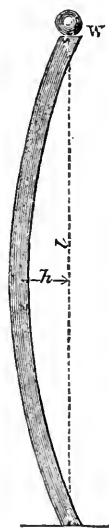
$\delta$  = the distance between the centres of tension and compression.

The longitudinal forces acting at the centre of the pillar are three, viz.: the weight,  $w$ , acting in the chord line of the curve, the resultant,  $C$ , acting at the centre of compression in the concave half, and the resultant,  $T$ , acting at the centre of tension in the convex half. Taking moments round either centre of strain, we have approximately

$$W \frac{T\partial}{h} = \frac{C\partial}{h}, \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad 1.$$

$h$  being assumed equal to the distance between the chord-line and either centre of strain, which is a close approximation when the pillar is very long in proportion to its width.\*

The values of  $T$  or  $c$  in different pillars are proportional to the number of fibres subject to strain, that is to  $b d$ , and  $\delta$  is obviously proportional to  $d$ ; so that we have the numerator on the right side of the



\* Mr. Hodgkinson's experiments show that this investigation is not applicable to cast iron pillars whose length is less than about 30 times their width: even with such short pillars it requires certain modifications, which he has deduced from experiment.

equation proportional to  $bd^2$ . Again, assuming that the deflection curve is a parabola, from which it can differ but slightly,\* we have

$$h = \frac{l^2}{8B};$$

but so long as the strain per sectional unit in the extreme fibres, to which their change of length is proportional, is constant,  $x$  will vary in the same ratio as  $d$ ; and we have, therefore,  $h$ , proportional to

$$\frac{l^2}{d}.$$

Whence, by substitution,

[illegible]

in which  $K$  is a constant depending on elasticity of the material, which may be determined by experiment.

If the pillar be round, and if  $d$  represent the diameter,

$$W = K \frac{d^4}{l^2}, \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad \cdot \quad 3.$$

which proves that the strength of long round pillars varies as the 4th power of their diameter, divided by the square of the length; and the longer the pillar is in proportion to its diameter, the nearer will this formula represent the truth.

As all the longitudinal forces at the middle of the pillar balance, we have the following equation:—

$$C = T + W,$$

which enables us to predict how a long pillar will fail, whether by the convex side tearing asunder, or by the concave side crushing. A wrought iron pillar, for instance, may be expected to fail on the concave side, as its power to resist crushing is less than that to resist extension. A long pillar of cast iron, on the contrary, will probably fail by the convex side tearing asunder, as the compressive strength of cast iron greatly exceeds its tenacity. Further, the effective strength of wrought iron to resist crushing is about 12 tons per square inch, while the tensile strength of cast iron is nearly 7 tons per square inch; and hence we may conclude that the strength of long similar pillars of wrought and cast iron will be nearly as 12 to 7.

It is also worthy of note that, if the same pillar be bent in different degrees,  $\tau$  will vary as  $h$ , while  $\delta$  remains constant; whence it follows from equation (1) that  $w$ , the weight which keeps the pillar bent, is nearly the same whether the flexure be greater or less. This statement would be accurately true, were it not that equation (1) on which it is founded, is only approximate. It will, however, agree very closely with experiment so long as  $h$  is considerable, that is, whenever the flexure is not slight. From this it follows, that any weight which will produce considerable flexure will be very near the breaking weight, as a trifling addition to it will bend the pillar very much more, and strain the fibres beyond what they can bear.

\* The curve will probably be intermediate between a parabola and a circle, approaching the latter if the pillar taper towards the ends.

## MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

*Notes of Shipbuilding and the Construction of Machinery in New York and vicinity.*

(Continued from page 45.)

*The Steamer Cosmopolitan.*—Hull built by John Englis, Greenpoint, L. I. Machinery constructed by Morgan Iron Works, New York. Owners, Sanford's Independent Line. Route of service, New York to Havana.

*Hull.*—Length on deck, 220 ft. Breadth of beam, 30 ft. 8 ins. Depth of hold to spar deck, 12 ft. Draft of water, 6 ft. Rig—schooner. Tonnage, 800 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 11 ft.

*Boilers.*—One—flue—located on deck, and uses a blower.

*Paddle Wheels.*—Diameter over boards, 31 ft. Material, wood. Have water-wheel guards fore and aft.

*Remarks.*—This vessel is of white oak and chestnut, and put together and braced in the most thorough manner. Its whole construction adds much credit to the excellent mechanical reputation of its builder.

*The Steamer Po-Yang.*—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Allaire Works, New York. Owners, Olyphant & Son, New York. Route of service, coast of China.

*Hull.*—Length on deck, 220 ft. Breadth of beam, 30 ft. Depth of hold, 11 ft. 6 ins. Draft of water, 7 ft. Frames—molded, 14 ins.—sided, 6 ins.—apart at centres, 18 to 23 ins. Tonnage, 756 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 12 ft.

*Boilers.*—Two—return tubular—located in hold. They are constructed of the best material and are of the most durable character.

*Paddle Wheels.*—Diameter over boards, 28 ft. Material, iron.

*Remarks.*—This vessel is of extraordinary strength, her materials being live oak, chestnut, &c. She is fastened with copper and tree-nails; and around her frames—iron straps, diagonal and double laid,  $3\frac{1}{4}$  by  $\frac{5}{8}$  inches—are placed, making them very secure. Her rig is that of a foretopsail schooner; her bunkers are of wood, and she has an enclosed forecastle, but no sponsons under water-wheel guards. She has two water-tight bulkheads, an independent steam fire and bilge pump, and the ordinary bilge injections. The whole construction of the *Po-Yang* is highly creditable to the skill of Messrs. Roosevelt, Joyce & Co., and gives great satisfaction to her owners.

*The Steamer J. W. Baldwin.*—Hull built by M. S. Allen, New York. Machinery constructed by Fletcher, Harrison & Co., New York. Owners, Romer & Tremper, New York. Route of service, New York to Rondout.

*Hull*.—Length on deck, 242 ft. Breadth of beam, 34 ft. 3 ins. Depth of hold, 9 ft. Draft of water, 5 ft. 3 ins. Frames—molded, 16 ins.—sided, 5 ins.—apart at centres, 24 ins. Tonnage, 680 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 60 ins. Length of stroke of piston, 11 ft.

*Boilers*.—Two—tubular—located on guards; have one blower to each, and no water-bottoms.

*Paddle Wheels*.—Diameter over boards, 30 ft. Material, iron.

*Remarks*.—This is an excellent vessel, and one well adapted to the wants of this much frequented route. Her frame is of white oak, chestnut, &c., and square fastened with copper and tree-nails.

*The Steamer T. V. Arrowsmith*.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co., New York. Owners, T. V. Arrowsmith & Co. Route of service, New York to Keyport.

*Hull*.—Length on deck, 200 ft. Breadth of beam, 27 ft. Depth of hold, 8 ft. 10 ins. Draft of water, 4 ft. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 23 ins. Tonnage, 450 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 44 ins. Length of stroke of piston, 10 ft.

*Boilers*.—One—flue—located in hold; uses a blower, and has no water-bottom.

*Paddle Wheels*.—Diameter over boards, 27 ft. Material, iron.

*Remarks*.—This vessel is constructed of white oak, chestnut, &c., and square fastened with copper and tree-nails. She is supplied with a steam pump, bilge injections, and the requisite fixtures essentially necessary for an excellent steamer.

*The Steamer Key West*.—Hull built by F. V. Tucker, New York. Machinery constructed by Daniel McLeod, Brooklyn, L. I. Owners, Hiram Benner & Co. Route of service, New York to New Orleans.

*Hull*.—Length on deck, 168 ft. 10 ins. Breadth of beam, 30 ft. Depth of hold, 11 ft. Do. to spar-deck, 18 ft. Draft of water, 10 ft. Frames—molded, 13 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, brigantine. Tonnage, 725 tons.

*Engines*.—Horizontal direct. Diameter of cylinders, 32 ins. Length of stroke of piston, 2 ft. 2 ins.

*Boilers*.—Two—tubular—located in hold, and do not use blowers.

*Propeller*.—Diameter, 10 ft. Pitch, 16 ft. Material, cast iron.

*Remarks*.—This vessel is of white oak, chestnut, &c., and is fastened with copper spikes and tree-nails. In her construction are combined strength, beauty of model, and speed. She is an excellent boat in every respect, and well worthy the excellent patronage she has received since she commenced to ply on this route.

*The Steamer Mary A. Boardman*.—Hull built by John Englis, New York. Machinery constructed by Neptune Iron Works, New York. Owners, Aymer & Co. In Government service.

*Hull*.—Length on deck, 160 ft. Breadth of beam, 27 ft. Depth of hold, 6 ft. Do. to spar-deck, 12 ft. Draft of water, 9 ft. Frames—molded, 13 ins.—sided, 6 and 7 ins.—apart at centres, 21 ins. Rig, schooner. Tonnage, 552 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 26 ins. Length of stroke of piston, 2 ft. 2 ins.

*Boilers.*—One—return flue—located in hold, and uses a blower.

*Propeller.*—Diameter, 9 ft. Pitch, 17 ft. Material, cast iron.

*Remarks.*—This vessel is of white oak, chestnut, &c., and square fastened with iron and tree-nails. Around the frames iron straps, diagonal and double laid,  $3\frac{1}{2}$  by  $\frac{5}{8}$  inches, are placed, thus rendering them very secure. This steamer is calculated to do excellent service wherever employed.

*The Steamer San Juan.*—Hull built by Maxson, Fish & Co., Mystic, Conn. Machinery constructed by Morgan Iron Works, New York. Owners, M. O. Roberts & Co., New York. Route of service, Lake Nicaragua.

*Hull.*—Length on deck, 160 ft. Breadth of beam, 25 ft. 6 ins. Depth of hold, 8 ft. 6 ins. Draft of water, 4 ft. 5 ins. Frames—molded, 12 ins.—sided, 10 ins.—apart at centres, 22 ins. Tonnage, 335 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 33 ins. Length of stroke of piston, 10 ft.

*Boilers.*—One—tubular—located in hold, and does not use blowers.

*Water Wheels.*—Diameter over boards, 26 ft. Material, wood and iron.

*Remarks.*—This is the first of some two or three new steamers designed by her owners to be employed in various ways upon their new route to California. She is an excellent vessel, and has so far as heard from, proved eminently successful. I trust her future career will be such as to prove pecuniarily remunerative to her owners. Her hull is of white oak, &c., and fastened in the securest manner.

*The Steamer City of Norwich.*—Hull built by John Englis, Greenpoint, L. I. Machinery constructed by Allaire Iron Works, New York. Owners, New York and Norwich Transportation Company. In Government service.

*Hull.*—Length on deck, 208 ft. Breadth of beam, 36 ft. Depth of hold, 12 ft. 6 ins. Draft of water, 5 ft. 3 ins. Frames—molded, 16 ins.—sided, 7 ins.—apart at centres, 25 ins. Tonnage, 890 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 52 ins. Length of stroke of piston, 10 ft.

*Boilers.*—One—tubular—located in hold, and does not use blowers.

*Water Wheels.*—Diameter over boards, 31 ft. Material, wood and iron.

*Remarks.*—This steamer is of white oak, &c., and in the manner of her fastenings has iron straps running diagonally around the frames, and also fore and aft, thus rendering them very secure.

*The Steamer Creole.*—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delamater, New York. Owners, Ludlam, Heineken & Co., New York. Route of service, New York to New Orleans.

*Hull.*—Length on deck, 194 ft. Breadth of beam, 34 ft. Depth of hold, 18 ft. 7 ins. Do. to spar-deck, 25 ft. 6 ins. Draft of water, 14 ft. Frames—molded, 15 ins.—sided, 8 ins.—apart at centres, 26 ins. Tonnage, 1100 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 36 ins. Length of stroke of piston, 3 ft.

*Boilers.*—One—return flue—located in hold, and uses a blower.

*Propeller.*—Diameter, 12 ft. Material, cast iron.

*Remarks.*—This vessel is of white oak, &c., and square fastened with copper and tree-nails. Around her frames—which are filled in solid—run iron straps, double and diagonal laid, 3 by  $\frac{5}{8}$  inches, making them secure and staunch. The *Creole* has made the run to New Orleans and back several times, and has during these trips, given great satisfaction to all connected with her.

*The Steamer Thomas Collyer.*—Hull built by Thomas Collyer, New York. Machinery constructed by H. R. Dunham, New York. Owners, Alliance Machine Company. Route of service, New York to Port Monmouth.

*Hull.*—Length on deck, 205 ft. Breadth of beam, 27 ft. Depth of hold, 9 ft. Draft of water, 4 ft. 6 ins. Frames—molded, 14 ins.—sided, 8 ins.—apart at centres, 25 ins. Tonnage, 506 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 48 ins. Length of stroke of piston, 10 ft.

*Boilers.*—One—tubular—located in hold, and uses a blower.

*Water Wheels.*—Diameter over boards, 27 ft. Material, wood.

*Remarks.*—This vessel is of white oak, chestnut, &c., and fastened with copper and tree-nails. She is furnished with an independent steam fire and bilge pump, and ordinary bilge injections. She is an excellent vessel for the route, and has given unqualified satisfaction during her period of service.

*The Steamer Hu-Quang.*—Hull built by Henry Steers, Greenpoint, L. I. Machinery constructed by Allaire Works, New York. Owners, J. M. Forbes & Co. Route of service, coast of China.

*Hull.*—Length of keel, 270 ft. Length on deck, 290 ft. Breadth of beam, 36 ft. 8 ins. Depth of hold, 14 ft. Do. to spar-deck, 20 ft. Draft of water, 8 ft. Frames—molded, 18 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, schooner. Tonnage, 1998 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 76 ins. Length of stroke of piston, 12 ft. Is fitted with Sickles' cut off.

*Boilers.*—Two—return flue. Length, 30 ft. 3 ins. Breadth, 12 ft. 6 ins. Height, 11 ft. Located in hold, and does not use blowers.

*Water Wheels.*—Diameter over boards, 28 ft. Face, 12 ft. Material, iron.

*Remarks.*—This vessel is built of white oak, cedar, and haemetac. Her model is one of much beauty, and her easy and graceful lines are such as to betoken great speed. She has iron straps, diagonal and double laid, running around her frames, securing them in the best possible manner, and making the vessel one of great strength. Her construction is another proof of the skill of American shipbuilders and American mechanics.

The Singapore (China) *Free Press*, of August 9th ult., referring to the trip of this vessel from New York to that port says: "The steamer *Hu-Quang* arrived here at 11, A. M., the 6th August, making the

quickest trip from America on record, being only 59 days 21 hours, exclusive of detentions for coaling, &c., at the intervening ports of St. Vincent, Simon's Bay and Mauritius. She made St. Vincent (Cape de Verdes) from New York, 28th May, at noon—distance 2897 knots—in 10 days 17 hours, and there remained 7 days 4 hours—leaving June 15, made Table Bay in 16½ days; lay-to 2 hours, and doubled the Cape of Good Hope, coming to anchor in Simon's Bay, after a run of 4 hours—the same day. At this place remained 8 days to coal, and left 10th July, at 2:30 P. M. Had rough weather on the African coast the following Saturday, and on Sunday in the Agullus current. Came to anchor in Port Louis, Mauritius, in 8½ days. Remained there 4 days, and left on 23d July, at 2 P. M.; encountered heavy seas during first 10 days out, and arrived from last mentioned port at Singapore, August 6, in 13 days 18 hours. Average speed, with 25 tons of coal per day, 12 knots. Best day's run on the passage, 325 knots; and least, 183 knots. On her trial trip, ran 17 statute miles in 53 minutes. Average speed from New York to this place, 11 knots."

*The Steamer Clifton.*—Hull built by J. Simonson, Greenpoint, L. I. Machinery constructed by Allaire Iron Works, New York. Owner, Cornelius Vanderbilt, New York. Route of service, New York to Staten Island.

*Hull.*—Length on deck, 185 ft. Breadth of beam, 34 ft. Depth of hold, 13 ft. 6 ins. Draft of water, 5 ft. 9 ins. Frames—molded, 15 ins.—sided, 7 ins.—apart at centres, 24 ins. Tonnage, 150 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 36 ins. Length of stroke of piston, 8 ft.

*Boilers.*—One—return flue—located in hold, and does not use blowers.

*Water Wheels.*—Diameter over boards, 26 ft. Material, iron.

*Remarks.*—This vessel is constructed of white oak, &c., and is securely fastened in the most approved manner. She has an independent steam fire and bilge pump, and ordinary bilge injections.

*The Steamer Trade Wind.*—Hull built by T. T. Wetmore. Machinery constructed by J. M. Huntington & Co. Owners, J. M. Huntington & Co. Route of service, New York to New Orleans.

*Hull.*—Length on deck, 135 ft. Breadth of beam, 26 ft. Depth of hold, 13 ft. Do. to spar-deck, 18 ft. 6 ins. Draft of water, 9 ft. Frames—molded, 10 ins.—sided, 10 and 8 ins.—apart at centres, 26 ins. Rig, three-masted schooner. Tonnage, 450 tons.

*Engines.*—Vertical direct. Diameter of cylinder, 36 ins. Length of stroke of piston, 2 ft. 6 ins.

*Boilers.*—One—flue—located in hold, and constructed of excellent material.

*Propeller.*—Diameter, 9 ft. Pitch, 18 ft. Material, cast iron.

*Remarks.*—This vessel is of white oak, chestnut, &c., and is square fastened with copper and tree-nails. She is admirably constructed, and well suited for the route now on, and the service engaged in, *i. e.* mail and passenger steamer.

*The Steamer United States.*—Hull built by C. & R. Poillon, Brook-

lyn, L. I. Machinery constructed by C. H. Delamater, New York. Owners, C. & R. Poillon. In Government service.

*Hull*.—Length on deck, 202 ft. Breadth of beam, 32 ft. Depth of hold, 12 ft. 3 ins. Do. to spar-deck, 19 ft. 3 ins. Draft of water, 12 ft. Frames—molded, 13 ins.—sided, 9 ins.—apart at centres, 24 ins. Rig, foretopsail schooner. Tonnage, 986 tons.

*Engines*.—Vertical direct. Diameter of cylinders, 36 ins. Length of stroke of piston, 3 ft.

*Boilers*.—One—flue—located in hold, and uses a blower.

*Propeller*.—Diameter, 13 ft. Pitch, 16 ft. Material, cast iron.

*Remarks*.—This vessel is of white oak, chestnut, locust, &c., and square fastened with copper and tree-nails. Iron straps, diagonal and double laid,  $3\frac{1}{2}$  by  $\frac{5}{8}$  inches, extend around them. Her model is without fault, and the short time she has been in service, has given the greatest satisfaction to all connected with her. Messrs. C. & R. Poillon may well feel proud of this excellent craft.

*The Steamer Kiang-Tsze*.—Hull built by Lawrence & Foulks, Williamsburgh, L. I. Machinery by Henry Esler & Co., Brooklyn, L. I. Owners, P. S. Forbes & Co. Route of service, coast of China.

*Hull*.—Length on deck, 200 ft. Breadth of beam, 33 ft. Depth of hold, 11 ft. 6 ins. Draft of water, 7 ft. 6 ins. Frames—molded, 15 ins.—sided, 6 ins.—apart at centres, 26 ins. Rig, foretopsail schooner. Tonnage, 1100 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 11 ft.

*Boilers*.—Two—return flue—located in hold, and does not use blowers.

*Water Wheels*.—Diameter over boards, 28 ft. Material, wrought iron.

*Remarks*.—This steamer is constructed of white oak, chestnut, &c., and very securely fastened with copper tree-nails, &c. Iron straps, diagonal and double laid, 4 by  $\frac{1}{2}$  inches, extend around the frames. The *Kiang-Tsze*, on the route of her future service, will tend to permanently enlarge the already established reputation of American ship-builders in the Chinese Empire.

*The Steamer George C. Collins*.—Hull built by George Goodspeed. Machinery constructed by Woodruff & Beach. Owners, New York and Hartford Steamboat Company. In Government service.

*Hull*.—Length on deck, 148 ft. Breadth of beam, 28 ft. Depth of hold, 7 ft. 6 ins. Draft of water, 6 ft. 6 ins. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 24 ins. Rig, schooner. Tonnage, 300 tons.

*Engines*.—Vertical direct. Diameter of cylinder, 36 ins. Length of stroke of piston, 2 ft. 6 ins.

*Boilers*.—One—tubular—located in hold, and uses a blower.

*Propeller*.—Diameter, 8 ft. 4 ins. Pitch, 15 ft. Material, cast iron.

*Remarks*.—This vessel is of white oak, chestnut, &c., and put together in an excellent manner. Since she has been in the service of the Government she has done good service, and given excellent satisfaction.

*The Steamers America and Union*.—Hulls built by Webb & Bell, Greenpoint, L. I. Machinery constructed by Henry Esler & Co.,



Brooklyn, L. I. Owners, Union Ferry Company. Route of service, New York to Brooklyn.

*Hulls*.—Length on deck, 160 ft. Breadth of beam, 32 ft. Depth of hold, 12 ft. 6 ins. Draft of water, 6 ft. 6 ins. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 23 ins. Tonnage, 509 tons.

*Engines*.—Inclined. Diameter of cylinder, 38 ins. Length of stroke of piston, 10 ft.

*Boilers*.—One—flue—located in hold, and does not use blowers.

*Water Wheels*.—Diameter over boards, 16 ft. Material, wood and iron.

*Remarks*.—These vessels are of white oak, &c., and fastened and rendered as secure and strong as practicable, their peculiar services demanding vessels capable of standing severe usage. I think their builders have been very successful in their construction.

*The Steamer City of Hudson*.—Hull built by T. C. Donaldson, New York. Machinery constructed by Fletcher, Harrison & Co., New York. Owners, Martin, Powers & Co., New York. Route of service, Catskill to Albany.

*Hull*.—Length on deck, 195 ft. Breadth of beam, 30 ft. Depth of hold, 7 ft. 9 ins. Draft of water, 4 ft. 3 ins. Frames—molded, 14 ins.—sided, 6 ins.—apart at centres, 24 ins. Tonnage, 512 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 44 ins. Length of stroke of piston, 10 ft.

*Boilers*.—One—return flue—located in hold, and does not use blowers.

*Water Wheels*.—Diameter over boards, 26 ft. Material, wood.

*Remarks*.—This vessel is of white oak, &c., and is very securely fastened and strapped. She has excellent accommodations, and has given much satisfaction whilst in service on her present route. B.

New York, January 21, 1863.

(To be Continued.)

## Changes in Iron.

From the London Builder, No. 1036.

At a recent meeting of the Manchester Literary and Philosophical Society, Mr. Dyer, Vice President, exhibited a broken screw bolt, 1½ inch square (used to fasten a cart-body to the axle). The fracture, near the head end, appeared very much like one of cast iron: imbedded in the centre of the bar was a smooth egg-shaped mass about ½-inch diameter, crossing the fracture, and leaving a cavity as its mould in the metal on one side. He assumed that faults like this were probably owing to the rapid processes in use for reducing masses from the puddle into bars of wrought iron, whilst the metal was only partially converted to the malleable state, as appeared in this sample of bad iron. The iron, in a semi-fluid state, is passed from the furnace through a succession of rollers, without re-heating or faggoting, as was formerly practised, and at once reduced to the sizes required. The improved rolling-mills could not, it seemed, insure improved qualities of wrought iron, whilst they afforded temptations to make it far infe-

rior to any that could have been made fifty years ago. Considering the many hazards to which life and property are exposed in traveling by railway and otherwise, from the iron "shuffled off in haste," and found in use in engineering constructions; it becomes important that previous tests should be employed to ascertain the real nature of the iron, so as to leave no question of its being in a safe condition for the purpose intended, and not like this specimen, and like much now-a-days made, by pressing the half converted puddle into marketable shapes.

In connexion with the subject of the slow changes which iron undergoes, M. Breguet, of Paris, stated that in their furnace for preparing soft iron, he had observed a remarkable case of crystallization of wrought iron. One of the furnace bars became brittle; and, on breaking a portion of it, he found it to contain a large cubical crystal of iron, each of whose sides measured five millimetres in length.

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### *Wright's Tar-Paving.*

From the London Mechanics' Magazine, December, 1862.

The many just complaints about the stone paving in the Inner Quadrangle of Somerset House, have at length been listened to. The whole of it has been taken up and the square covered with Wright's tar-paving, which is said to have been used with success at Woolwich and other Government works. The finishing layer of this material will not be put down until the spring of next year. It will then be fairly open to public criticism, and we shall take the opportunity of describing the process of its manufacture, its advantages, and the effect of weather and continual traffic upon it.

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### *Iron Masts.*

From the London Builder, No. 1038.

The following are the dimensions and weight of the masts sent to Pembroke from the Chepstow Ironworks, for the use of her Majesty's ship *Prince Consort*. The mainmast is 116 feet long by 37 inches in circumference, and weighs 18 tons 14 cwt.; the foremast is 110 feet long by 36 inches in circumference, and weighs 17 tons 10 cwt.; the mizenmast is 83 feet long by 24 inches in circumference, and weighs 5 tons 14 cwt.; the bowsprit is 43 feet long by 36 inches in circumference, and weighs 4 tons 10 cwt.

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For the Journal of the Franklin Institute.

*Strength of Cast Iron and Timber Pillars:* A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By WM. BRYSON, Civ. Eng.

(Continued from Vol. xliv, p. 347.)

The pintles employed in the construction of the Pemberton Mill, in the lowest room, as O. B. M. says, "were 3 inches in diameter, 16 $\frac{3}{4}$  inches from bottom to underside of flanch; flanch 7 inches in diameter, 1 $\frac{1}{8}$  thick, supported by pillars 6 inches in diameter."

In a previous table—Vol. xlv., page 48—I have shown the calculated breaking weight of the pintle, proper, irregularly fixed to be 223 tons, one-fourth of which is 55 tons for the assumed safe weight.

The breaking weight of the flanch of the pintle, as given by Mr. Francis, he thought “would not be far from forty-five tons,” that of O. B. M. “66,512 lbs.,”  $\div 2240 = 29.69$  tons.

If the top bed of the flanch of the pintle had been turned off, or faced in the lathe, as it should have been, and the bottom of the pillar, six inches external diameter, and five-eighths of an inch thick, also turned so that the pillar would be accurately fitted to and firmly fixed on the top of the flanch, the pressure being uniformly distributed, then the breaking weight of the flanch of the pintle, if considered as a series of beams fixed at one end and loaded at the other, and that the ultimate pressure terminated at or on the line of the inner circumference of the pillar, seven-eighths of an inch from the neck of the pintle, and computed by either of the following formulæ, is 38 tons, or 28 tons if taken on the line of the mean circumference, and I have no doubt but that the flanch was capable of sustaining much greater pressure than I have obtained by calculation.

Formulæ for the strength of a rectangular beam fixed at one end and loaded at the other, Low Moor iron No. 3:

$$\begin{aligned} \left( w = \frac{f b d^2}{n L} \right) \quad \left( w = \frac{526 b d^2}{l} \right) \quad \left( w = \frac{4.5 b d^2 467}{4 L} \right) \\ \left( w = \frac{11.258 b d^2}{4 L} \right) \quad \left( w = \frac{2.8145 b d^2}{L} \right) \end{aligned}$$

$f$  = tensile strength per square inch = 14,535 pounds.

$b$  = breadth in inches.

$d$  = depth in inches.

$n$  = 2.3.

$L$  = length in inches.

$l$  = length in feet.

$w$  = breaking weight in pounds  $\div 2240$  = tons.

$w$  = breaking weight in tons.

But as the breaking weight of the flanch of the pintle can scarcely be viewed in this manner, it being a case depending on the tensile strength of the iron, which for Low Moor iron No. 3 is 14,535 pounds = 68.8 tons, and assuming that only one-third of the circumference of the pillar rested on the flanch, then the breaking weight is  $68.8 \div 3 = 22.93$  tons, and taking one-third of this it becomes 7.64 tons for the assumed safe weight, or taking one-sixth of the breaking weight for the whole flanch, it becomes 11.46 tons, or about equal to the assumed safe weight of the pillar.

From what information I have been able to obtain, it does not appear that any calculation for the strength of the pillars of the Pemberton Mill has been given in any of the evidence, but Capt. Bigelow stated that "The pillars were made tenfold stronger than required, according to sustain the weight which they held," and in his letter he says, "it is abundantly proved that the bad casting of the iron columns was the main cause of the disaster. Obtained from the source and in the manner they were, no calculation or allowance of strength would have been of any avail as security. These columns were calculated to bear only one-tenth of the breaking weight; and I apprehend that very few engineers in the world would say that a greater margin of security than this was needed." Mr. Francis stated, "about twenty-five tons on each of the lower columns," would be between one-ninth and one-tenth of the breaking weight, as calculated by Hodgkinson's rule, of the columns in the lower story."

O. B. M. says, "the largest pillars were in the first story or weave room, and measured 5 inches in diameter at the smallest part near the top,  $12\frac{1}{2}$  feet long, and their mean thickness  $\frac{5}{8}$  of an inch;" the pillars in the second story, he says, "I find them  $4\frac{1}{2}$  at the small end, with a mean thickness of  $\frac{5}{8}$ ths of an inch, and  $11\frac{1}{2}$  feet long;" and again he says, "Since the disaster I have examined the thickness of several pillars in the mills at Lawrence, and find but little variation, the greatest not exceeding  $\frac{3}{8}$ ths of an inch." "But it seems if we would use iron to the best economy for strength, the pillars should be largest in the middle or at least straight."

I have no hesitation in saying that, even admitting the above dimension pillars to have been perfect castings, and that they were five-eighths of an inch thick, that from the manner of construction of the whole building they were totally inadequate for such a cotton factory as the Pemberton Mill, as the safe dead load should not on such pillars have exceeded 11.40 tons in the lower story, and 9.79 tons in the second story, by taking one-tenth of the calculated breaking weight for flat ends firmly fixed, or 12.45 tons in the former and 10.31 tons in the latter by taking one-fourth of the calculated breaking weight if irregularly fixed, and yet it has been shown that the estimated dead weight on the lower pillars was actually 25 tons; this, then, is only a trifle less than one-fourth of the calculated breaking weight, for a dead load, for the pillars in the lower story, even if they had been accurately fitted with flat ends and firmly fixed, and is not therefore either one-ninth or one-tenth of the breaking weight. I presume that the pillars in the lower story should not have been permanently loaded with more than 9 tons; and those in the second with more than  $7\frac{1}{2}$  tons.

Having already given so many calculations for the breaking weight of similar pillars as those employed in the Pemberton Mill, I will conclude the calculations on this subject by giving the following table, which is computed from Mr. Hodgkinson's formulæ for the strength of pillars, and shows the breaking weight and one-fourth and one-tenth of the

breaking weight calculated as hollow uniform cylindrical pillars with both ends flat and firmly fixed, for the smaller diameter, it being more critically correct than by taking the mean diameter; also the breaking weight and assumed safe weight of the same pillars with rounded ends or irregularly fixed, and for different thicknesses of metal.

The following formula is deduced from Mr. Hodgkinson's experiments on pillars of Low Moor iron No. 2, 10 feet long and from  $2\frac{1}{2}$  to 4 inches diameter :

$$w = 46.65 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$$

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Flat and Firmly Fixed.*

Length or height of Pillar in feet.	External diameter in inches.	Thickness of Metal. Inch.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formulae $w = 46.65 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$ $r = \frac{w c}{w + \frac{3}{4} c}$	Assumed safe weight $\frac{1}{4}$ of the breaking weight. Tons.	One-tenth of the breaking weight in tons.
12.5	5.	3.5	30.	118.32	29.58	11.83
11.5	4.5	"	30.66	101.61	25.40	10.16
				$w = 44.34 \frac{D^{3.55} - d^{3.55}}{L^{1.7}}$ $r = \frac{w c}{w + \frac{3}{4} c}$		
12.5	5.	3.5	30.	114.05	28.51	11.40
11.5	4.5	"	30.66	97.90	24.47	9.79

*Hollow Uniform Cylindrical Pillars of Cast Iron, Both Ends being Rounded or Irregularly Fixed.*

				Calculated breaking weight in tons from formula $w = 13 \frac{D^{3.76} - d^{3.76}}{L^{1.7}}$	
12.5	5.	5.8	30.	49.83	12.45
"	"	9.16	"	46.47	11.61
"	"	1.2	"	42.81	10.70
"	"	7.16	"	38.81	9.70
"	"	3.8	"	34.47	8.61
"	"	5.16	"	29.75	7.43
"	"	1.4	"	24.65	6.16
"	"	3.16	"	19.15	4.78
"	"	1.8	"	13.22	3.30
11.5	4.5	5.8	30.66	41.26	10.31
"	"	9.16	"	38.63	9.65
"	"	1.2	"	35.73	8.93
"	"	7.16	"	32.52	8.13
"	"	3.8	"	29.00	7.25
"	"	5.16	"	25.14	6.28
"	"	1.4	"	20.91	5.22
"	"	3.16	"	16.31	4.07
"	"	1.8	"	11.30	2.82

"Three weeks after the accident, the following statement was made of the number of sufferers :

" Killed outright 83, since dead 3, total dead,	86
Badly injured,	116
Injured, but not seriously,	159
Total killed and wounded,	361"

What was the cause of all this suffering and what was the cause of the fall of the mill, the verdict, which I believe to be just, fair, and impartial, says "that the direct cause of the fall of this mill was the weakness and insufficiency of the cast iron shoring, &c."

I am inclined to the opinion that the cause was attributable not only to the weakness of the pillars and imperfection of the casting, but from the undue overloading, which was two to one or more for such pillars of the limit of safety for a dead load, and that the primary cause was produced or originated by the moving of the four fly frames, which it was thought by Samuel W. Jackson, "weighed 8500 pounds a piece" = 3.79 tons. I have no doubt but that some of the pillars were loaded with a live load equivalent to the dead load or calculated breaking weight of irregularly fixed pillars, or to about one-third of the calculated breaking weight of the same pillars, if firmly fixed, which is far from one-tenth of the breaking weight.

Cast iron being a crystalline material, brittle and uncertain, I am aware that all consistent allowance ought to be made in case of the failure of a body composed of it. Castings having all the appearance of soundness may contain imperfections not externally observable, and the permanent condition of well cast pillars is liable to be affected by the constant motion of the machinery and the operatives in a factory, and of course their condition will more rapidly be affected when badly cast and imperfectly set.

A poor casting, such as an imperfectly cast eccentric hollow cylindrical iron pillar subject to vibration, may be considered analogous to failing human nature, fragile, deficient, weak, overworked, overloaded beyond its strength, it may survive for one, two, three, aye even six years, and by receiving some sudden vibratory shock be broken down, sooner or later, but it would eventually occur as in the case of the cotton factory known as the Pemberton Mill.

*Solid Uniform Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.*

Length or height of Pillar in feet.	Side of the square in inches.	Number of diameters contained in the length or height.	Value of $w$ in tons from formula. $w = 10.95 \frac{d^4}{L^3}$	Value of $c$ .	Calculated breaking weight in tons from formula. $Y = \frac{w d}{w + \frac{3}{4} c}$	Strength per square inch of section in tons.
6	10	7.2	3041.66	345.1	318.03	3.18
7	"	8.4	2231.69	"	309.27	3.09
8	"	9.6	1710.93	"	299.75	2.99
9	"	10.8	1351.85	"	289.64	2.89
10	"	12.	1095.00	"	279.12	2.79
11	"	13.2	904.95	"	268.35	2.68
12	"	14.4	760.41	"	257.46	2.57
13	"	15.6	647.92	"	246.59	2.46
14	"	16.8	558.67	"	235.84	2.35
15	"	18.	486.66	"	225.28	2.25
16	"	19.2	427.73	"	215.00	2.15
17	"	20.4	378.89	"	205.03	2.05
18	"	21.6	337.96	"	195.43	1.95
19	"	22.8	303.32	"	186.20	1.86
20	"	24.	273.75	"	177.38	1.77
21	"	25.2	248.29	"	168.96	1.68
22	"	26.4	226.23	"	160.95	1.60
23	"	27.6	206.79	"	153.35	1.53
24	"	28.8	190.10	"	146.13	1.46
25	"	30.	175.20	"	139.30	1.39
26	"	31.2	161.98	"	132.84	1.32
27	"	32.4	150.20	"	126.72	1.26
28	"	33.6	139.66	"	120.95	1.20
29	"	34.8	130.20	"	115.50	1.15
30	"	36.	121.66	"	110.34	1.10

*Solid Uniform Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.*

			$w = 7.81 \frac{d^4}{L^3}$			
8	10	9.6	1220.31	294.	249.00	2.49
9	"	10.8	964.19	"	239.27	2.39
10	"	12.	781.00	"	229.27	2.29
11	"	13.2	645.45	"	219.13	2.19
12	"	14.4	542.36	"	209.02	2.09
13	"	15.6	462.13	"	199.03	1.99
14	"	16.8	398.46	"	189.26	1.89
15	"	18.8	347.11	"	179.78	1.79
16	"	19.2	305.07	"	170.65	1.70
17	"	20.4	270.24	"	161.89	1.61
18	"	21.6	241.04	"	153.54	1.53
19	"	22.8	216.34	"	145.60	1.45
20	"	24.	195.25	"	138.07	1.38
21	"	25.2	177.09	"	130.95	1.30
22	"	26.4	161.36	"	124.23	1.24
23	"	27.6	147.63	"	117.90	1.17
24	"	28.8	135.59	"	111.94	1.11
25	"	30.	124.96	"	106.34	1.06
26	"	31.2	115.53	"	101.07	1.01
27	"	32.4	107.18	"	96.13	0.96
28	"	33.6	99.61	"	91.48	0.91
29	"	34.8	92.86	"	87.12	0.87
30	"	36.	86.77	"	83.02	0.83

*Solid Uniform Cylindrical Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.*

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Value of $w$ in tons from formula. $w = 6.71 \frac{D^4}{L^2}$	Value of $c$ .	Calculated breaking weight in tons from formula. $Y = \frac{wc}{w + \frac{3}{4}c}$	Strength per sq. inch of section in tons.
8	10	9.6	1048.43	271.04	227.02	2.89
9	"	10.8	828.39	"	217.60	2.77
10	"	12.	671.00	"	208.02	2.64
11	"	13.2	554.54	"	198.33	2.52
12	"	14.4	465.97	"	188.71	2.40
13	"	15.6	397.04	"	179.26	2.28
14	"	16.8	342.34	"	170.05	2.16
15	"	18.	298.22	"	161.17	2.05
16	"	19.2	262.10	"	152.64	1.94
17	"	20.4	232.17	"	144.51	1.83
18	"	21.6	207.09	"	136.77	1.74
19	"	22.8	185.87	"	129.45	1.64
20	"	24.	167.75	"	122.54	1.56
21	"	25.2	152.15	"	116.02	1.47
22	"	26.4	138.63	"	109.89	1.39
23	"	27.6	126.84	"	104.14	1.32
24	"	28.8	116.49	"	98.73	1.25
25	"	30.	107.36	"	93.67	1.19
26	"	31.2	99.26	"	88.92	1.13
27	"	32.4	92.04	"	84.47	1.07
28	"	33.6	85.58	"	80.30	1.02
29	"	34.8	79.78	"	76.39	0.97
30	"	36.	74.55	"	72.72	0.92

*Solid Uniform Cylindrical Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.*

			$w = 4.79 \frac{D^4}{L^2}$			
6	10	7.2	1330.55	230.9	204.30	2.60
7	"	8.4	977.55	"	196.15	2.49
8	"	9.6	748.43	"	187.51	2.38
9	"	10.8	591.35	"	178.59	2.27
10	"	12.	479.00	"	169.58	2.15
11	"	13.2	395.86	"	160.63	2.04
12	"	14.4	332.63	"	151.84	1.93
13	"	15.6	283.43	"	143.32	1.82
14	"	16.8	244.38	"	135.13	1.72
15	"	18.	212.88	"	127.32	1.62
16	"	19.2	187.10	"	119.91	1.52
17	"	20.4	165.74	"	112.91	1.43
18	"	21.6	147.33	"	106.33	1.35
19	"	22.8	132.63	"	100.16	1.27
20	"	24.	119.75	"	94.39	1.20
21	"	25.2	108.61	"	88.99	1.13
22	"	26.4	98.96	"	83.96	1.06
23	"	27.6	90.54	"	79.27	1.00
24	"	28.8	83.15	"	74.90	0.95
25	"	30.	76.64	"	70.83	0.90
26	"	31.2	70.85	"	67.04	0.85
27	"	32.4	65.70	"	63.50	0.80
28	"	33.6	61.09	"	60.21	0.76
			Calculated breaking weight from the above formula.			
29	"	34.8	56.95	..	.	0.72
30	"	36.	53.22	..	.	0.67

(To be Continued.)



*On Iron-clad Ships, with Plans and Specifications of an armored Corvette proposed for the United States Government.* By JOHN W. NYSTROM, C. E.

Armored ships are yet experiments, and a subject now of considerable importance in this country. It is a rather difficult undertaking to combine all requirements of an iron-clad man-of-war, particularly for one of small size and for shallow water. The most important requirements are,—*impregnability, speed, superior ordnance, good sea-going and sailing qualities, comfort on board, simplicity and no complicated machinery, and lateral strength of the hull of the ship*, all of which are to a certain extent combined in the corvette about to be described.

In August, 1861, and February, 1862, the Navy Department at Washington invited the ingenuity of the country to make proposals for the construction and building of iron-clad steamers, which was at both times promptly responded to by a great many plans, of which the corvette herein described is one of the two submitted by the writer.

The two sizes of armored steamers which I proposed to build were constructed to accommodate the stipulations in the Navy Department's advertisement. It is, however, believed that smaller boats would answer better for the present requirement peculiar to the country, but in all cases small gun-boats are best suited for home service; a greater number could be built in a shorter time, which would be more effective in blockading the long American coast. Armored gun-boats of 125 feet long, 20 feet wide, with only 7 feet draft of water, mounting one or two heavy guns, could go by inland navigation from New York to Fortress Monroe; they could even be made to draw 10 feet water by taking in coal and ordnance after arriving in sufficiently deep water. The object of which would be to surprise or attack an enemy's fleet at Sandy Hook, Delaware Bay, or in the Chesapeake. If the Navy Department would allow themselves to part from the Erie experiment principle and employ our present knowledge in steam engineering, gun-boats of this size could easily be made to carry fuel for six days steaming. A number of small gun-boats are not so easily surprised, and if a blunder is made in one or more of them the risk is not so great as in a line-of-battle. They are, however, easier managed, and if damaged they can go behind islands and shoals out of the reach of the enemy's fire. An experimental gun-boat of this size could be built in two months, and if proved successful almost any number could be built in the next two or three months.

Armored ships must yet be considered an experiment, for which a number of large ones bears a greater risk in expense and blunders. The large size armored steamers built in European navies are intended more for service abroad, for which they are well suited and less expensive than a number of small ones, but our case is of a different nature.

In the Russian war with England and France, an English naval officer proposed a plan by which to attack and bombard Cronstadt

with a number of small gun-boats, which was considered the most safe and effective, but peace was restored and the plan abandoned.

A corvette on the plan about to be described will be as *impregnable* as any iron-clad now building in Europe. As regards *speed*, the conditions set forth in the Navy advertisement were such that speed could not possibly be attained, for the greatest speed I can with safety guarantee is 10 knots, but am able to construct an iron-clad of the same or smaller size with 15 knots per hour. Although speed is of great importance, there are no men-of-war in the U. S. Navy with good speed, and some of the iron-clads lately built, can hardly walk by themselves, but must have a tow-boat to help them along; also the gun-boats built on the Erie experiment principle can only walk.

The sea-going and sailing qualities of the corvette will be as good as that of any merchant vessel of the same proportions; it is in every respect a ship-shaped vessel. A man-of-war may come in battle once or twice, or say a dozen times in a lifetime; it would be improper to sacrifice *comfort, health, and life* for some temporary importance; in the corvette proper attention is paid to comfort of officers and men on board by a house placed between the cupolas on the main deck. This house does not interfere with the proper management of a battle,—should it be injured by the enemy, *repair it*,—should it be shot away entirely, *build a new one*.

The *lateral strength* of an armored ship for shallow water, requires the greatest consideration both in design and workmanship; wooden vessels can hardly be made strong enough for that purpose. An iron-clad now building at the Philadelphia Navy Yard will hardly have lateral strength enough for the waves inside the Delaware breakwater.

*Specification of an armored corvette with six 11-inch guns.*—Figure 1, Plate III, represents the outer appearance of the corvette, with two armor cupolas on deck, in each of which are to be placed three 11-inch guns.

Figure 2 is a longitudinal section, showing the internal arrangement, and fig. 3 a plan of the boat; the arrows show the limit of angle in which the guns can be trained in each port-hole.

Figure 4 is a transverse section through the line A B, figs. 2 and 3, showing the armor guards and cupola with one gun. The armor guards above the water-line are at an angle of  $45^{\circ}$  and of 5 inches thick iron plates; under the water-line the guards are at an angle of  $67\frac{1}{2}^{\circ}$ , and of 3 inches thick iron plates.

Figure 5 is a plan of the cupola, showing the three guns, of which it is proposed to use two at a time, and have one for reserve in case the others should get injured or hot during the firing. With some practice it might be possible to employ the three guns at the same time, depending on the enemy's position.

#### DIMENSIONS OF THE BOAT.

Length on the water-line,	.	225 feet.
Breadth of beam moulded,	.	40 "
Extreme breadth over guards,	.	45 "
Draft of water,	.	12 "
Greatest immersed cross section,	.	436 square feet.

Greatest cross section including guards,	450 square feet.
Displacement,	2125 tons.
Speed in miles per hour,	10 knots.
Horse power of engines,	900 horses.

The corvette to be made wholly of iron, with two propellers, and schooner rigged.

*Description of Iron Work.—Keel.*—The centre keel to be of plate iron  $1\frac{1}{4}$  inches thick, by about 2 feet wide, bent to suit the form of the boat; also two keels of solid rolled beam iron 12 inches deep, one on each side, as shown in fig. 4.

*Sternpost* to be of wrought iron in one piece, with a stuffing-box and heel for the rudder, as shown in fig. 2.

*Sternpost* to be made in one piece from deck to keel, as shown in fig. 2.

*Plating.*—The hull to be of  $\frac{3}{4}$ -inch plate iron, lapped longitudinally and butt-jointed vertically, the butts to be double riveted in each plate. The streaks to be about 3 feet wide from centre to centre of rivets, except in the stern and bow, where it diminishes according to the ordinary mode of iron shipbuilding. All the seams to be caulked, in and outside. The  $\frac{3}{4}$ -inch iron plating to extend in about 150 feet under the guards, the balance at the stern and bow to be plated with 4 inches thick iron plates above the water-line; from the water-line to 6 feet depth, to be plated with three inches plates; from 6 feet under water-line the keel to be plated with  $\frac{3}{4}$ -inch iron, except in the bow, where one streak from 6 to about 9 feet depth to be 2 inches, and from 9 to about 12 feet depth to be 1 inch thick. The butt pieces in the armor streaks to be  $1\frac{1}{2}$  inches thick, screwed on with  $1\frac{1}{2}$  inches tap screws,  $2\frac{1}{2}$  inches into the 4 inch armor plates; under the water-line the butt pieces are to be riveted.

*Ram.*—The ram of the corvette is to be formed by the armor-plates, terminating in the form of the stem, as shown in fig. 2. The object of making the ram in this round shape, is to distribute evenly on the vessel the shock of a collision; also for preventing the ram sticking fast in the vessel run into. The rams now made for some vessels in the Navy, with a small piece of iron sticking out from the stem, is a rather unsafe contrivance; should it stick fast for only one minute, the enemy's vessel will likely be hung upon it, which may give time enough for the enemy to board us, and should the enemy's vessel have a velocity forward while attempting to run into it, the ram may be broken off and injure our vessel more than the enemy. The *Merrimac's* ram was broken while running into our vessels in Hampton Roads.

*Frames.*—The frames to be spaced 18 inches apart; every other of beam iron, solid rolled 12 inches deep, and every other of beam iron  $\frac{3}{4}$  (6 + 4) inches. The frames to be in as long pieces as possible with broken joints. In the most curved parts of the stern and bow where it is not possible to bevel the beam iron, the frames to be made of  $\frac{3}{4}$  (6 + 4) inches angle iron; also the frames on the bulkheads to be of the same iron.

*Beams.*—The beams to be of beam iron, solid rolled, 12 inches deep, spaced 3 feet apart, one on every other frame, bent at the gunwales in continuation of the frames, as shown in fig. 4. The joints of the frames and beams to be riveted with butt pieces  $\frac{3}{4}$ -inch thick by 3 feet long, one on each side, with one inch rivets. The beams over the bulkheads to be of angle iron  $\frac{3}{4}$  (6 + 4) inches. Under deck beams to be 6 inches solid rolled beam iron, riveted to the frames as shown in fig. 4. Under each cupola to be 6 intermediate beams of 9 inches solid rolled beam iron, as shown in the section fig. 2.

*Stringers.*—The gunwale stringer to be of plate iron 1 (12 + 12) inches, firmly riveted to the iron deck and side of the vessel, as shown in fig. 4. The stringers to circumscribe the entire vessel.

*Keelsons.*—To have three keelsons, the centre one to be of solid rolled beam iron 12 inches, and one on each side of 9 inches, spaced 9 feet 6 inches apart, as shown in fig. 4. The keelsons to be firmly riveted to each frame.

*Longitudinal Beams* to be of 9 inches solid rolled beam iron, spaced 9 feet 6 inches apart, and firmly riveted to the deck beams.

*Bulkheads.*—To have five water-tight bulkheads of  $\frac{1}{2}$ -inch iron diagonal on both sides with angle iron  $\frac{1}{2}$  (3 + 2) inches, as shown in fig. 4.

*Decks.*—To have two decks, the upper one to be of  $1\frac{1}{2}$  inches thick plate iron next to the beams, butt-jointed in all seams with  $\frac{3}{4}$ -inch butt pieces; the longitudinal seams to run in one line, and broken cross seams. The iron deck to be covered with 8 inches thick planks, screwed fast from underneath. The under deck to be of  $\frac{1}{2}$ -inch iron with longitudinal lap seams and butt-jointed cross-seams, covered with 4 inch thick plank, screwed fast from underneath.

*Rudder.*—To have a balance rudder of wrought iron, fitted so as to be protected from enemy's shots. The rudder to be worked either in the pilot house on deck, or under deck in the mariners' room abaft. I have made this kind of rudder on several steamers in Russia, and found it to answer exceedingly well; it has many advantages above the single rudder,—it is easier managed, the vessels steer better with it, and it is less affected by the sea,—fig. 2 shows how it is arranged.

*Armor Cupolas.*—To have two armor cupolas on the main deck, of a spherical form, 25 feet diameter at the base and 10 feet high. The armor plates to be 6 inches thick, jointed in 12 segments with 8 inches solid rolled beam iron, as shown by fig. 6. Each cupola to have six port holes, in which the guns can be trained in a horizontal angle of  $90^\circ$ , and vertically about  $47^\circ$ . The port holes to be 3 feet wide by 4 feet high, covered with a sliding shutter  $4\frac{1}{2}$  inches thick, as shown by figs. 4 and 5. The shutters to be worked from the inside. Each cupola to admit firing in a horizontal angle of  $330^\circ$ . The tops of the cupolas to have a hatchway 6 feet in diameter, covered with a plate  $4\frac{1}{2}$  inches thick, which latter to have a hole 2 feet in diameter, covered with an iron grating. Cupolas of this description are considered strong enough without any backing of wood, which latter would greatly interfere with the proper training of the guns. The spherical form ren-

ders them as strong as 9 inches thick flat iron, and exposes the least possible surface to the enemy.

*Armor Guards.*—The armor guards to extend about 185 feet on each side of the boat; the armor plates to be 5 inches thick, placed on wood at an angle of  $45^\circ$  from the water-line to the bulwark, as shown in fig. 4. The plates to be fastened with tap bolts from the gunwale stringer, and with screw bolts at the lower edge or water-line, through the wood to the hull of the boat. The armor plates will be 6 feet 6 inches wide, and in as long pieces as possible, but not less than 10 feet. The lower armor plates to be 3 inches thick, by 5 feet wide, placed at an angle of  $67\frac{1}{2}^\circ$ . The wood backing to be of the hardest dry oak. The ends of the armor plates to be butt-jointed, but not riveted; under each cross-joint of the 5 inch plates to be laid a butt piece 2 inches thick by 9 inches wide, fitted into the wood, and under the 3 inch plates a similar butt piece  $1\frac{1}{2}$  inches thick. The guards to extend on each side to where the armor plates of the stern and bow commence, so that nothing of the  $\frac{3}{4}$ -inch plating will be exposed.

An armor plate placed at an angle, increases in horizontal thickness as the *secant* of the angle of inclination to the vertical plan. On this principle English engineers argue that a vertical plate of the same horizontal thickness as the inclined one has the same strength; which theory will hold good as regards lateral strength,—but it is the reflecting power which is taken advantage of in the inclined plate. The reflecting power is in proportion as the *tangent* of the angle of inclination; that the *secant* and the *tangent* added together, and the sum multiplied by the true thickness of the inclined plate, will give the relative value to the vertical one. The lateral strength of an armor plate is in proportion as the square of the thickness when the breaking force acts slowly,—but in the sudden shock of a projectile, the inertia of the armor plate acts as a die in a punching machine, where the resistance of the plate is in proportion direct as the thickness.

*Deck Fittings.*—*Bulwark* to be of wood boarded with 3 inches plank, intended to be made fast and not to be saved in a battle, but should it be desired to make it removable it can easily be made so.

*Capstans.*—To have two capstans, one forward and the other abaft, arranged so that each can be worked by any number of men from 1 to 16, without change of gearing or other complicated machinery; also to be made so as to pinch hold of any size of chain or hemp cable.

*Deck Lights.*—To have deck lights to the officers' and mariners' rooms, as shown in the plan, fig. 3,—with frames ground water-tight in the deck, and arranged so as to be easily opened for ventilation under deck; also to be provided with stand pipes of about 2 feet high above deck, for ventilation in rainy or stormy weather.

*Davits.*—To have two anchor davits in the bow, and eight boat davits, two for each boat, as shown in figs. 2 and 3.

*House on Deck.*—To have a house on deck of an elliptical form, as shown by the strong dotted lines fig. 3; length 85 feet by 20 feet wide,

to be made wholly of iron about  $\frac{1}{4}$ -inch thick. The window shutters to be made of  $\frac{1}{2}$ -inch iron, perforated with rifle holes. The roof beams of the house to be made of angle iron  $\frac{3}{8}$  ( $2\frac{1}{2} + 3$ ) inches, covered with iron plates  $\frac{1}{8}$ -inch thick, on the top of which to be wooden boards  $1\frac{1}{2}$  inches thick. The house to contain two kitchens, dining room for officers, cabin, &c., and arranged to suit the requirement. The top of the house to be circumscribed by a brass railing. To have two iron stairways, one forward and one abaft of the cupolas. The house is not intended to be saved in time of battle; if a ball should strike it there will only be a hole. All the furniture in it to be made of iron or other incombustible materials, that it cannot take fire.

*Water Closets.*—To have two water closets on the fore deck, mounted on hinges, so that they can be felled down when it is required to fire forward. Also water closets under deck with pumps.

*Pilot House.*—To have a pilot house made wholly of iron, located as shown in figs. 1, 2, and 3. During a battle the helmsman is stationed in the mariners' room abaft, and is directed by a dial worked from either of the cupolas.

*Rigging.*—To be three-masted schooner-rigged, as shown by fig. 1. All standing rigging to be of wire rope. It is schooner-rigged for the sake of making it simple, and the least possible number of ropes.

*Life Boats.*—To have four life boats of the most approved form, complete, with oars.

*Hatchways.*—To have nine hatchways, covered with spherical armor plates as shown in fig. 2. The two hatchways in each cupola to be covered with flat plates level with the floor. The combings to be of iron, riveted to the iron deck and projecting one foot above the wooden deck.

*Figure-head and Bowsprit* are arranged so that they can be removed in one minute, when the stem is a ram for running into an enemy's vessel.

*Accommodation.*—Under main deck is a space of 114 feet in length, occupying the whole width of the boat, of which 48 feet is abaft and 66 feet forward; also a forecastle of 30 feet to the stem; all to be arranged in the most suitable manner for officers, mariners, and crew. The water tanks are placed under the lower deck, as shown on the drawing, fig. 2, arranged with pumps, cocks, and pipes, as may be required.

*Machinery.*—The machinery, to consist of two horizontal condensing engines, working separately, each on a propeller shaft, as shown on the drawing figs. 2 and 3; to be of the most simple construction and most efficient in its performance, arranged with expansion, superheating of steam, and fresh water condenser, all up with the present knowledge of steam engines.

#### DIMENSIONS OF ENGINES.

Diameter of cylinders,	.	.	.	.	42 inches.
Stroke of piston,	.	.	.	.	30 "
Pressure of steam,	.	.	.	.	50 lbs.
Expansion	$\frac{3}{4}$	to	$\frac{1}{2}$ .		
Actual horse power engines,	.	.	.	.	900 horses
Propellers, diameter,	.	.	.	.	10 feet.

**Steam Boilers.**—To have three cylindrical boilers of the most simple construction; every part of the inside to be accessible for cleaning.

Outside diameter 9 feet by 15 feet long.

Area of fire-grate, . . . . .	96 square feet.
Fire surface, . . . . .	2880 " "
Consumption of fuel per hour, . . . . .	2450 lbs.
Consumption of fuel per day of 24 hours, . . . . .	26.3 tons.
Consumption of fuel per seven days, . . . . .	160 "

**Ventilators.**—To have two ventilators (fans) in the engine room, each 42 ins. diameter by 15 ins. wide. Air pipes to lead under the fire-grates, between decks and cupolas, as may be required for ventilating the ship.

**Donkey.**—To have one donkey engine with double-acting pump, arranged with cocks and pipes, so as to be used for feeding the boilers, bilge-pump, and fire engine.

**Propellers.**—To have two brass propellers 10 feet in diameter, each with four blades, arranged on the shafts so as to be easily shipped or unshipped as may be required at sea.

**Coal-bunkers.**—To have coal bunkers divided into two water-tight compartments, with capacity for 100 tons of coal.

**Ordnance.**—The ordnance to consist of six 11-inch guns, three in each cupola, mounted on carriages made wholly of wrought iron. The gun carriages to be mounted each on three wheels on vertical spindles turned in the direction the gun is desired to be moved. The two wheels under the gun to be turned by a worm screw, and the hind wheel by a lever; the course of the gun to be steered by the lever both in the recoil and when moving it. The floor in the cupolas to be made of iron and perfectly flat, that the guns can be hauled on it in any direction. When the gun is to be fired, the two wheels are turned cross-wise with the screw, the recoil is then taken partly by the friction of those wheels on the floor, and the balance by a friction wheel around which is a chain or hemp cable fastened with one end in the cupola. By this arrangement the guns can easily be trained in a horizontal angle of 90° in each port-hole. The axis of the guns will be only 7 feet above the water-line, for which it would rarely be required to dip it under the horizon, but should it be required to fire in the direction *ab* fig. 4, the enemy must be very near, when the bulwark is of little importance; fire it away, and the projectile will strike the water at a distance of 19 yards. The guns can be elevated to an angle of 35°. At the circumference in the cupola are six holes *d, d*, of about 1.4 inches diameter, for handing up ammunition during firing. If more complicated gun carriages are adopted, it will necessarily throw out one of the three guns in each cupola.

Under the cupolas are steam hoisting machines *H*, fig. 4, composed simply of a cylinder 12 inches diameter by 15 feet stroke, to be used for hauling the guns, which dispenses with a great number of men and confusion in the cupolas. With 50 lbs. of steam, the machine can pull 2½ tons.

The principal armor plates in the vessel herein described are independent of the hull of the same. Should it at any time be desired

to dispense with the heavy armor, it can easily be removed and there remains a comfortable and well proportioned steamer. It is practically demonstrated by the *Warrior* that it is not good to make the principal armor plates constitute the hull of the vessel, for the difficulty of keeping it tight after having worked in heavy sea. It is also believed that it is not practical to combine iron and wood in the hull of an armored vessel, particularly for shallow draft, but even the size of *La Gloire* has proved a failure in that respect, and the objection will become more serious for lighter draft. A vessel can be considered a long girder, of which the strength is in proportion as the square of the depth. Neither is it practicable to make water-tight bulkheads and iron decks in a wooden vessel, for one material will tear the other to pieces in a heavy sea.

It may be remarked that the anchors and propellers are not protected by a bill and tail as in the Monitors; to which I beg to reply that if the tail really protected the propeller, and if it could be made so as not to injure the speed and sea-going quality, and not endanger the safety of the ship, it would be proper to put such a thing on; but, as long as that is doubtful, it is preferable to avoid the trap, in consideration that it is better to lose both the propellers in a battle, than to have the vessel foundered at sea, before it reaches the enemy. It is of equal importance to get safe into a battle as to get safe out of it—both the purposes should be equalized and not neglected. The temporary importance of the bill and tail makes the vessel more unsafe out of battle than in the battle. The chance of a propeller being hit in the water is very rare: at any rate, it would be better to make the propellers of cast iron, and with at least four blades each, so that if it should be struck by a projectile, one blade may break off without further injury to the shaft or the stern-bearing. Two propellers would have eight blades, and suppose that even seven of them were shot away, still the steamer would make a good speed with the one blade left. If a blade of a brass propeller is struck, its strength does more harm to the shaft and stern of the vessel than if broken off; and it may bend so as to prevent the propeller from turning in its determined space.

An armored steamer as herein described will cost 850,000 dollars, complete for sea, but without ordnance and ammunition. On account of preparations necessary for the heavy armor plates, which in the cupola will weigh about  $6\frac{1}{2}$  tons each, it will require 12 months to complete one such steamer. It can be built on my own shipwharf, and the machinery, boilers, and armor plates manufactured in my own establishment located at Gloucester City, N. J., opposite Philadelphia.

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*Mr. Nasmyth's Improved Form of Link Motion.\**

From the *Practical Mechanic's Journal*, Dec. 1862.

In many important applications of the Steam Engine, it is essential that we should possess the means of reversing at pleasure the direction of the revolution of the crank shaft.

\* The above is the substance of a communication made by James Nasmyth to Section G, at the recent meeting of the British Association at Cambridge, Oct. 2, 1862.



Prominent instances of the desirableness of this capability are presented in the case of the locomotive and in the marine engine, as also in the case of "winding engines," as employed in colliery and other mining purposes.

Many contrivances have been resorted to for the attainment of the object in question, all of which, however, have been characterized by considerable complexity, and consequent liability to derangement, unfaithfulness of action, as well as rapid wear and tear.

It was not until the invention and introduction of the justly celebrated "link motion," that the problem of how to reverse the motion of a steam engine received its *perfect* solution, at the hands of a mechanic in the service of Robert Stephenson & Co., of Newcastle-upon-Tyne, who in the invention of the link motion, added one of the most beautiful and perfect details to the steam engine, and has thereby conferred a vast benefit on mankind. Not only does the "link motion," solve the problem of "how to reverse the action of the steam engine;" but also by its means we obtain at the same time a variable expansive valve motion, combined with a means of arresting in the most gentle, yet effective manner, the motion of the steam engine, and in these respects combines in one beautifully simple whole, the properties of reversing gear, expansive valve gear, and throttle valve, all in one.

So perfect in all these respects is the action of the link motion, that the form first given to it by its inventors has been universally accepted, and became traditionary, in so far at all events as regards the loop or link form of its main and distinguishing feature is concerned. In the application of this beautiful invention to marine engines of the largest class, some disadvantages latent in the *loop* or link power begin to manifest themselves; the chief of which is the constructive difficulty of taking up the slack naturally due to the wear and tear of the swivel block, working inside the loop of the link, and the consequent unpleasant knocking action and increased wear which naturally accompanies any such undue slackness in the moving parts. Besides which, in order to give the requisite amount of rigidity to the large size of link employed in engines of the most powerful class, an amount of material has to be introduced which is in every respect desirable to avoid.

It was with the view to remove these objections, as well as to simplify and economize the cost of construction of such link motions, that Mr. Nasmyth contrived in 1852 what he terms his "*solid bar*" form of the link motion, and which he in the same year first introduced into actual machinery in a colliery winding engine which he made for a firm in South Yorkshire.

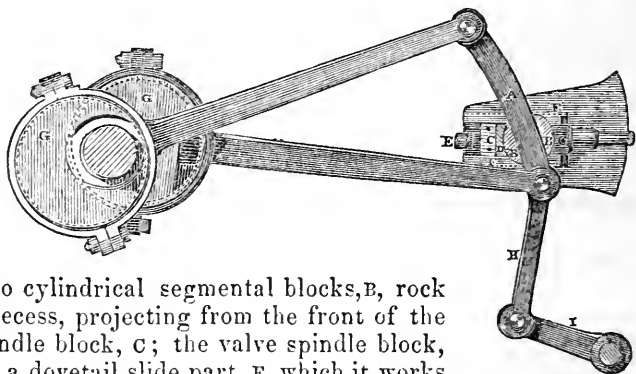
The perfect action in practice which was found to attend this simple "solid bar" form of the link motion, led his friend Mr. Edward Humphrys to introduce this solid bar link motion into his marine engines, in doing which, Mr. Humphrys has displayed his usual high skill and judgment, in the admirable manner in which he has adapted Mr. Nasmyth's invention, as may be seen in those magnificent marine engines

of 400 horse power, which Mr. Humphry's firm has sent to the great Exhibition of 1862.

As it is presumed that this subject can only interest those practically conversant with the details of steam engines, it will not be requisite to enter into any detailed description of "the link motion," as such, but simply to point out the nature of the modifications of form which specially characterize Mr. Nasmyth's arrangement of it—the main feature of which consists in the substitution of a solid bar, A, in the accompanying engravings, in place of the usual link or loop form of the part in question.

This solid bar, A, is coupled with the sliding block, C, to which the valve rod is attached, by means of two cylindrical segmental rocking blocks, B, between which the bar, A, slides, where one or other of the eccentrics is caused to convey its chief action to the valve.

The substitution of the simple solid bar, *a*, for the open link or loop hitherto employed, is not only more rigid and exact in its action, as well as economical in its construction and material, but by means of the setting up pad piece, *d*, and its set screw, *E*, all "slack" due to wear and tear can be removed, and the most perfect yet easy fit secured.



The two cylindrical segmental blocks, B, rock inside a recess, projecting from the front of the valve spindle block, C; the valve spindle block, C, having a dovetail slide part, F, which it works on, and which may be secured to or made part and parcel of the frame of the engine, and so secure most perfect exact action to the motion of the valve block, C, and its attached valve rod.

The lever, I, and connecting bar, H, are the means whereby the one or other eccentric, is made to convey its chief action to the valve in the usual manner.

A cover plate attached to the slide block, C, by four small bolts, the holes for which are indicated, keeps the slide or link bar, A, and the rocking segments, B, in their respective positions, and renders them easily accessible when need be.

Fig. 4.

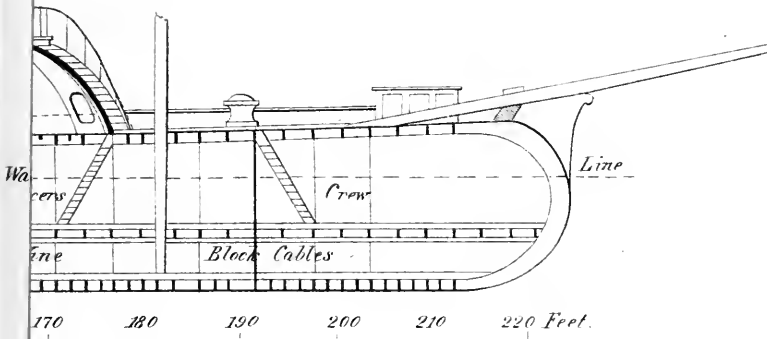
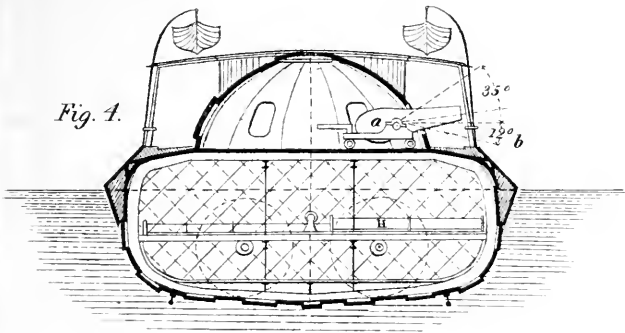
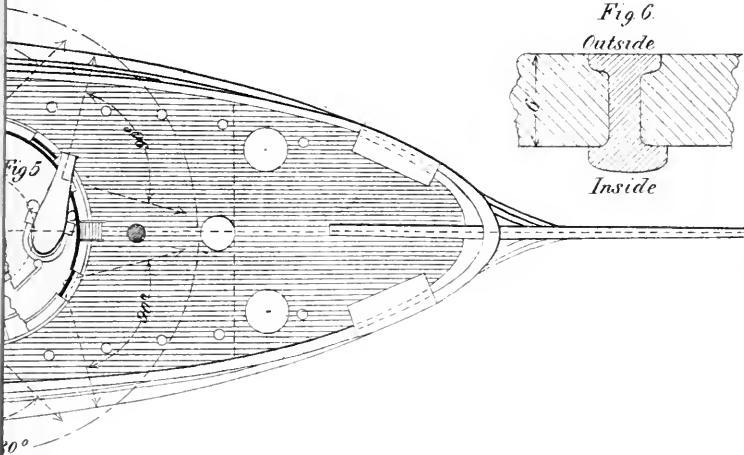
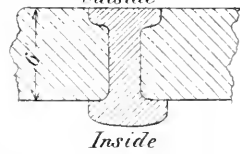


Fig. 6.  
Outside



# AN ARMORED CORVETTE WITH SIX GUNS

Proposed by John W Nystrom C.E.

Fig 1

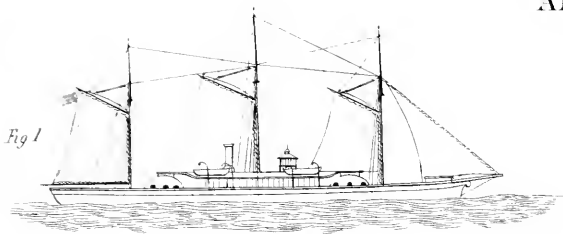


Fig 4

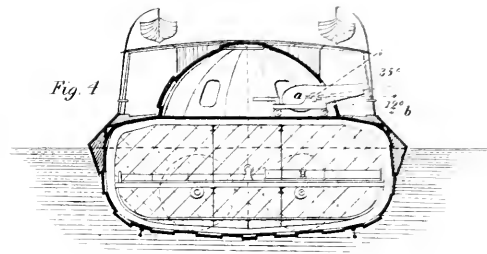


Fig 2

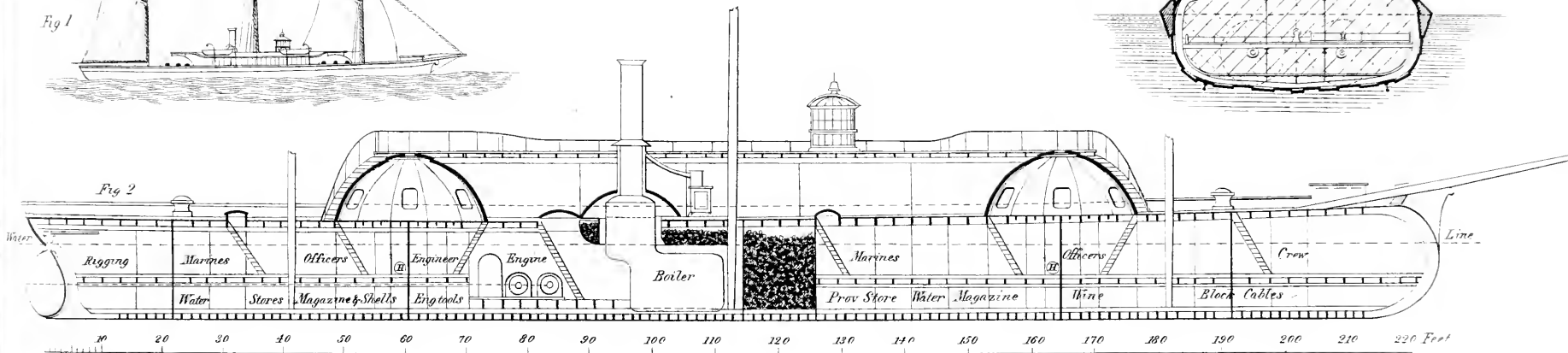


Fig 3

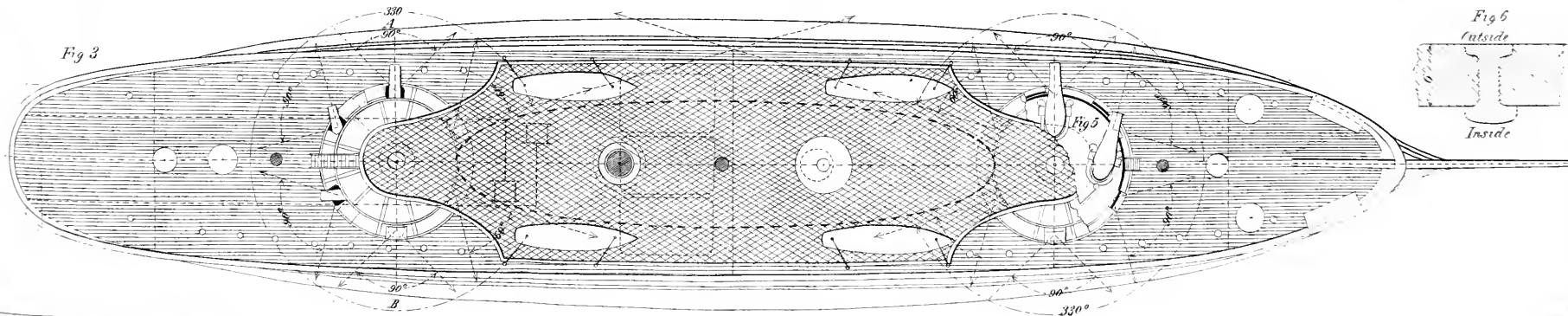
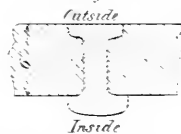


Fig 6



*Iron-Built Armor-Plated Vessels.*

From the London Artizan, Feb., 1863.

On the 19th ult., Mr. T. Barras read a very interesting paper in the theatre of the Royal United Service Institution, on the proposed plan for a wholly iron-made armor-plated vessel. Captain Fishbourne, R. N., occupied the chair. The view taken by Mr. Barras of the subject was of a three-fold character. He said such a ship as he proposed should be regarded hydrostatically, as a body designed to float; mechanically, as a beam subject to great pressure; and in the third place as a battery designed for purpose of attack and defence. A ship to be constructed on his principle should have a flat bottom amidships, where the boilers and coal bunkers were, and should be constructed wholly of iron, in three sheets of iron plates, riveted together in such a manner as to be protected either by an outer or inner coat of the plating. He strongly objected to a ship built of mixed materials differing widely from each other in chemical properties, as they never could work in harmony together. One point connected with the present construction of ships demanded consideration, and that was the destructive electrical action which took place in salt water with mixed constructions of iron and wood, with fastenings of brass. It was this electrical action that caused the high ratio of illness occurring in the finest armor-plated ships, and the curious results elicited by *La Goire*. As for the present system of shipbuilding, the probable results might be anticipated—the most serious and ruinous expenses would be gone to on ships that could not be expected to last for a dozen years; while a ship constructed as he proposed, he ventured to affirm would be an efficient ship for half a century, if not longer. Mr. Barras entered into particulars, tending to show that the vessel thus put together would answer all purposes for which she would be required.

For the Journal of the Franklin Institute.

*On the Economy Resulting from the Expansion of Steam.*

By W. BARNET LE VAN.

A great deal has been said lately in regard to expansion and full travel of steam, and reference has been made to Hecker Brothers' "Metropolitan" flour-mill, where engines with cut-offs were tried with less economy, they assert, than when the same used steam during full travel of piston, which are now in operation at their mill.

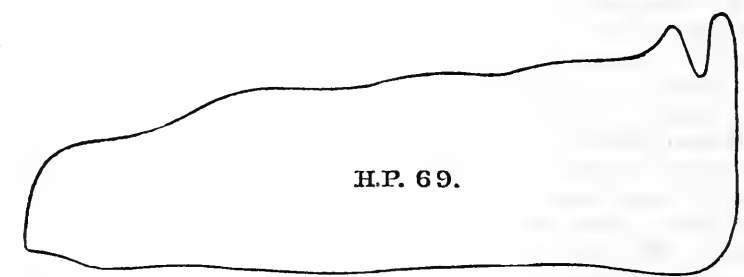
It is stated in public print that with the present arrangement they can make one barrel of flour by the use of 50 pounds of coal, and this is considered one of the good results of full travel.

The following diagrams were taken from different sets of engines which operated under nearly the same circumstances; if any difference the full travel engines had the advantage, as shown below.

Card Fig. 1 was taken from the full travel engines, diagrams from each engine being alike after having been put in good running order by one of the best shops in this city; the party being in no way concerned in taking the diagrams or replacing the engines. At the time

the diagrams were taken, the engines were running day and night continuously, and the experiments were prolonged to two weeks. The *best* result showed that 2000 pounds of coal made 45 barrels of flour; in other words, to manufacture one barrel of flour 44.45 pounds of coal were required.

Fig. 1.

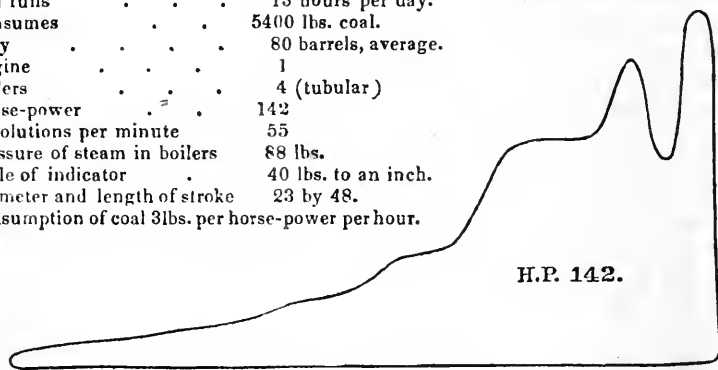


Mill runs day and night for	6 days, or 144 hours.
Consumes	50 tons coal.
Duty	45 barrels per ton.
Engines	2
Boilers	4 (tubular).
Horse-power	69 each.
Revolutions per minute	55
Pressure of steam in boilers in lbs.	100
Scale of indicator	40 lbs. to an inch.
Diameter and length of stroke	16 by 30.
Consumption of coal, $5\frac{1}{2}$ lbs. per horse-power per hour.	

Card Fig. 2 was taken from an engine supplied with an *adjustable cut-off* and put in place of the *full travel* engines mentioned above—boilers, machinery and duration of trial the same. Instead of running day and night, the time of run was 13 hours; during the remaining 11 hours the fires were “banked” and engine and machinery allowed to stand. The average result, under these circumstances, was 80 barrels of flour to the ton of coal (2000 pounds), which is 25 pounds to the barrel.

Fig. 2.

Mill runs	13 hours per day.
Consumes	5400 lbs. coal.
Duty	80 barrels, average.
Engine	1
Boilers	4 (tubular)
Horse-power	142
Revolutions per minute	55
Pressure of steam in boilers	88 lbs.
Scale of indicator	40 lbs. to an inch.
Diameter and length of stroke	23 by 48.
Consumption of coal 3lbs. per horse-power per hour.	



The builders of the adjustable cut-off engine guarantied 45 per

cent. more work, with the same amount of fuel, than the full travel engines. The result shows a saving of 80 per cent.

I present these facts for the consideration of those who are interested in the subject.

Philadelphia, Feb., 1863.

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*Ventilation of Iron-Cased Frigates.*

From the London Artizan, Feb., 1863.

The plan of ventilation which is now being carried out on board the frigate *Royal Oak*, under the direction of Captain Fanshawe, who is the inventor of the system, differs in several respects from the method hitherto adopted for securing ventilation for our large line-of-battle and other ships. As applied to the *Royal Oak*, and other armor-plated vessels of the same class, it promises to be exceedingly effective. In securing a ventilation of the main deck, comparative little difficulty will be experienced; it is therefore in the lower deck that the method recommended by Captain Fanshawe will be more particularly adopted. The masts of the *Royal Oak*, being of iron, and all hollow, advantage is taken of this to make them air-shafts for carrying off the vitiated air from each deck. An aperture is accordingly made in each mast, which being opened and closed at pleasure, permits the foul air, of all the decks to be carried upwards. The different berths, stores, and compartments on the deck, instead of being closed up as in ordinary vessels, are supplied with gratings by which the foul air may escape. The essential point in Capt. Fanshawe's system is that there shall be a constant current of air circulating in every portion of the vessel, approximating as closely as possible to the upward and downward currents of a mine.

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Translated for the Journal of the Franklin Institute.

*Air-Bubble Thermometer, with two Indexes.* Communicated to the Philomathic Society of Paris, by M. E. BARBIER, *Astronome-Adjoint* of the Paris Observatory.

*I.—Thermometer Indicating at the same time the Maximum and Minimum.*

1. *Idea of the Air-Bubble Thermometer.*—The minimum thermometer of Rutherford contains an enamel index which the alcohol draws with it as it contracts, but which it does not push forward in expanding. All its movements are retractions. M. Doulcet saw badly made indexes remain stationary when they ought to have retrograded; remarking that they fell to the liquid meniscus by the action of their weight, he got the idea of his maximum-thermometer.

If in an alcohol thermometer, the bulb upward, there be placed an index in the form of a blunt pin, so that this index will fall with its point foremost, the pin will stop at the meniscus of the alcohol, and will follow it if it move by an elevation of the temperature, but

will remain in its place if from the effect of cold the meniscus rises. This index, which thus by its point denotes a maximum, is of remarkable steadiness, the tube may be shaken smartly without altering its indication.

The Doucet thermometer indicates the maxima as well as the minima, and gives its minima like a good Rutherford thermometer. But the reversed position of the instrument permits (especially at the moment when the meniscus is pierced by the point of the index) a portion of the liquid to trickle along the walls of the tube. This is the principal inconvenience of the Doucet thermometer.

As an accident suggested it to him, so it was an accident which led me to devise the air-bubble thermometer.

A Doucet thermometer which I was carrying from Nice to Cannes, fell twelve feet upon the turnpike road, which was at that season fortunately covered with a thick coat of dust. The cotton packing and sheet-iron case prevented the breaking of the glass, but not the rupture of the liquid column of the thermometer; five or six bubbles of air separated the alcohol into various parts, in one of which the index was contained. Having leisure, I endeavored to restore the continuity of the liquid column without the assistance of force or great heat.

I hoped that the movement of the liquid produced by the heat of the hand and that of the index as the tube was placed in different positions, would suffice. I soon succeeded in leaving in the tube but one bubble, upon which the head of the index rested, but this poor ram could not overcome this small bubble, and I conceived the idea of using the resistance of bubbles for the construction of a thermometer. Two indexes of a pin-form, having their heads turned towards a bubble, should be pushed, the one in one direction, the other in the other.

In the month of July last, I communicated this idea to the *Society of Science, Letters, and Arts* of Nice, presenting to them the Doucet thermometer. My examinations having recalled me to Paris, I thought of realizing the idea which I had imagined. I had a second index placed in a Doucet thermometer, and having developed a bubble of air so as to separate the two indexes, I had the satisfaction of seeing in the same horizontal tube an index which moved only forward, and another moving only backward; a maximum and a minimum index.

It seemed to me that the extreme temperatures given by the same instrument, left to itself, would be strictly comparable; and that, moreover, the leaking which took place in the Doucet thermometer would be in great part avoided by the horizontal position of the tube. My experiments lead me to believe that this thermometer, easily carried and adjusted without assistance, except from the hands of the observer, will be found useful in meteorological observations. I did not hesitate to present to M. Leverrier a note, which he kindly read to the Academy of Sciences.

With a thermometer about fourteen inches long, and weighing with



its case about 3 oz., maximum and minimum determinations may be made to  $0^{\circ} \cdot 2$  cent. ( $0^{\circ} \cdot 36$  Fahr.) M. Marié-Davy and M. Renou have been kind enough to begin the study of this thermometer.

2. *Method of Observation.*—The point indicated by the head of the minimum-index is first read, then that by the head of the maximum-index; the bulb of the thermometer is then warmed while it is in a vertical position, with its bulb down, in order that the maximum-index may be in the alcohol; when it is entirely immersed, the temperature of the bulb is lowered below the maximum which is next to be observed, and the instrument is suddenly inverted, the head of the two indexes approach each other and are now separated only by the air-bubble. The instrument placed horizontally is then ready to give a new maximum and minimum. The bubble of air resists all movements, provided there be no shock sufficient to cause new ones. If the instrument be deranged by a very violent jerk or a considerable blow, it is easily put in condition to give again its indications.

3. *Correction.*—Each index may be considered as indicating by its head the extremity of a thermometric column. The zeros of these imaginary thermometers will be at the points where the heads of the indexes would be when the bulb of the thermometer is buried in ice.

*Double Tell-tale Thermometer.*—Imagine at a certain point in a vertical thermometer tube whose bulb is downwards, a bubble of air transpierced by an index whose head is upwards; and outside of the liquid a second index sticking to the side of the tube with its head downwards. The thermometer thus arranged would show by the fall of one or both indexes, that the one or the other of the two corresponding temperatures had been passed, or that the temperature has not remained within the limits assigned by the placing of the two indexes. Such an instrument would be valuable in a hot-house, and particularly in a cocoonery, where it is important that an observable phenomenon, besides the death of the worms, should announce to the master that the overseer has been negligent. The use of a magnifying-glass renders the indexes easy of observation.

## II.—*Movement of an Index in the Tube—Phenomena Observed.*

1. An index falls head foremost when the thermometer is suddenly reversed. This is the Rutherford index, and is easily displaced in the tube.

2. An index is easily introduced by its point, the thermometer, held horizontally and gradually inclined, being slowly turned in the hand; when the point is once engaged in the tube, the thermometer is suddenly and completely inverted; the index falls through the liquid column to the meniscus, which it follows in its movements, produced by a rise of temperature, but not at all in those produced by cold. This is a maximum Doucet index; and when abandoned by the alcohol it is remarkably stable.

3. An air-bubble resists the penetration of the head of an index. It

can be only made to penetrate it by striking the tube on the palm of the hand, while the index is guided by the other, without holding it.

4. An index coming in contact with an air-bubble by its point, penetrates it either by change of temperature or by a blow on the palm of the hand.

5. An index of which one portion is out of the liquid, cannot be moved except by a shock.

6. If a change of temperature brings a drop of alcohol into contact with the point of an index which is entirely or partially out of the liquid, the bubble will, if it be close above the index, trickle along it from the point to the head, and if the tube be shaken will run down along the walls.

7. When the indexes touch each other, head to head, and the instrument being held bulb upwards, the meniscus of alcohol is brought by cooling, to the point of contact of the indexes, a strangulation of the column takes place by which a small bubble of air is introduced, which mounts along the upper index. These bubbles form regularly and unite above into one, which soon acquires proper dimensions. The thermometer is then warmed to give the separated portion of the liquid a sufficient length; and by subsequently cooling with the bulb down, the lower index is lodged in the separated column, and by the cooling moves from the upper. You have then a minimum vertical thermometer; if the instrument be heated, you have the tell-tale, &c.

By this mechanical method of producing the air-bubble, these thermometers can be rapidly made without requiring any peculiar skill in the operator.—*L'Institut*.

### *Gunpowder made of Paper.*

From the Lond. Mechanics' Magazine, December, 1862.

We read in a Copenhagen letter:—The Royal Artillery, some days ago, made experiments with gunpowder made of paper, which turned out a success. Common packing paper was, in the course of 10 or 15 minutes, transformed into a very powerful kind of gunpowder, and a number of different shots were fired with it. The invention, which seems to be very interesting, belongs to a foreigner.

For the Journal of the Franklin Institute.

*Locks and Safes.* Discussion in the Polytechnic Association, New York, Friday Evening, Jan. 16, 1863. Communicated by J. D. STETSON, Secretary.

S. D. Tillman, Esq., in the Chair.

J. P. Frazer, of New York City, exhibited and explained his Door-fastener. It is intended to be used by travelers as an additional security to the door, and consists of two pieces of metal and a screw. One of the pieces hooks into the cavity where the spring-bolt stands, and the other piece is inserted through a mortise, and stands across so as to take hold of the door and door-frame. The screw tightens the connexion and makes a perfectly firm job. The piece that extends across is so formed, that, by turning it over, the device may

be adapted to rim-locks or mortise-locks, as may be required, and the screw is of sufficient length to compensate for all irregularities and inequalities in the thickness of the work. Several members commented on it, and expressed favorable opinions of its merits.

Mr. Stetson, in alluding to the faults of ordinary locks, their liability to be turned by forceps if the key is left in the door, and their liability to be picked by simple instruments from the outside, (this requiring very little skill) if the key is withdrawn, explained how the difficulty might be partially obviated, either with or without a device like this of Mr. Frazer. The plan—not original with him—was to withdraw the key partially from the door, and to place a wash-bowl or pitcher under it in such a manner that any interference with the lock would probably detach the key and cause an alarm by its fall.

Mr. Bull introduced Mr. Hobbs, of London Crystal Palace celebrity, who was listened to with great interest.

Mr. Hobbs explained the general nature of Locks. They were all capable of division into three great classes, or in fact two, one of the two being again subdivided. The first class was the ward lock, in which the security depended on the introduction of a greater or less number of impediments skilfully distributed so that an elaborately shaped key was required to pass them and move the bolt. These were easily opened after the very simple operation of taking an impression of the wards by wax or a smoked key. The second general class was the tumbler lock, in which the security depended on the employment of movable obstacles, which all required to be removed, and which could not be thus avoided. The single tumblers originally provided were levers which might be avoided by elevating them, either just sufficiently or to any extent more than sufficient. These were soon replaced by the double tumbler, in which a notch was introduced in the lever, and a lifting of the lever or tumbler too much, would be as ineffective as not lifting it at all. These locks were, however, readily picked by a gradual feeling of the right position of each tumbler, which right position, when gained, was easily detected by a skilful operator. Mr. Hobbs explained here the great refinement to which this branch of the art had been carried. He declared it impossible to file or otherwise produce a series of tumblers of so uniform a size or length that all, even if mounted with the greatest delicacy on the same cylindrical pin, would be equally pressed upon by the stump, or the projection on the bolt, which struck them. If all *were* equally pressed, the removal of one or the removal of its resistance to the bolt by turning it until its notch matched the stump, would release the bolt so that the latter would move sensibly back, it being understood that a constant and tolerably severe strain was kept up on the bolt during this operation. In other words, the elasticity of metal is such, that in a lock of ten tumblers, if all bore equally to resist the strain applied by a burglar on the bolt, the bolt would move back until it met and pressed firmly against these several tumblers and there stop. If now the burglar, by turn-

ing one tumbler gradually around, puts it in such position that the notch matches the stump, so as to relieve that tumbler from its share of the strain, the whole strain being thrown upon the other nine, would compress those nine further than before, and the bolt would move. The extent of this motion would be, of course, very slight, but it was appreciable and actually measureable; he had a micrometer which multiplied the extent of each motion 20,000 times; a variation in the position of the bolt equal to a thickness of tissue paper, would be indicated by his instrument to the thickness of twenty reams of such paper.

The skill of lockmakers had always kept in advance of the skill of burglars, and he believed it always would. The manufacture of locks was progressing very rapidly. It had made progress within the past year. Before the burglars had really learned this mode just described, of picking, lockmakers introduced what were known as false notches, notches of one-eighth inch depth, or sufficient to relieve entirely the strain on the tumblers, and to cause the lock to behave in all respects as if that tumbler had been placed in its proper position, and yet when all the rest had been really properly placed, the bolt could not be withdrawn, but would only move to the small extent allowed by the false notch, and would then be stopped as effectually as before. But this, in turn, could be readily surmounted by skill and patience. It mainly required the latter alone to adjust successively all the tumblers of the most elaborate locks, no matter what number of false notches were employed.

The second division of the tumbler locks, a branch of the lock family which might perhaps be designated with some propriety as an entirely independent one, though resting in fact upon the same tumbler principle before explained, was the dial lock or letter lock, called by the latter name in consequence of its being customary to designate the position of the dials or indices employed by the letters of the alphabet. These had no key. That was the distinguishing feature of this kind of lock. Some of the most recent varieties of the other division, it should have been remarked, were made without keyholes, or rather locks were so made in some instances that the keyhole was closed while the lock was being operated. In such locks the key was introduced and turned round and caused to fulfil its functions, while all access to the interior of the lock was closed by a plate or strong covering. But the dial lock had neither key nor keyhole. It depended on the placing of the tumblers in right positions by the turning of parts on the outside, either the same part being turned successively in various positions, and thereby adjusting the interior parts, or by the adjustment of several dials or rings, separately exposed on the exterior. Some of these locks were very easily picked or opened, but others, both of this class and of the other, the double tumbler lock with keys, Mr. Hobbs thought, were, in the present state of the art, unpickable. He believed that the art was advancing, that every lock now known would ultimately—probably very soon—be overcome by the skill, not, he hoped, of actual burglars, but of those amateurs,

or rather of those students who, in the interest of the community, studied to perfect the constructions, by discovering and remedying their weaknesses.

All locksmiths, even those engaged in the manufacture of the most ordinary locks, understood, if they did not practice, picking by pressure. But the cheap locks were generally sufficient for ordinary purposes. A perfectly impregnable lock was not needed on a street door, or on any other door where a jackknife could remove a panel, and, as a general thing, the cheap locks were as perfect in their line, and perhaps advancing as rapidly towards still higher perfection, as the more costly structures. The Secretary had explained his mode of securing his door in hotels. He (Mr. H.) would explain his, which consisted in turning a chair upside down and resting it delicately against the door so that any movement would throw it down.

His (Mr. Hobbs') success in England had been adverted to by others. He had found the condition of affairs in England with regard to the protection of property, very different from that here. They relied more upon watchmen there. Their watchmen were not ignorant and careless laborers, but well trained men who had served for generations in the same business and knew nothing else but banks and the safety of bank property. They were born in banks and died in banks. He carried the Day & Newell lock to England, and when he had been successful in picking the famous Chubb lock in the Great Exhibition, gave the Chubb parties an opportunity to recover their money, by offering the same premium to any who would pick his Day & Newell construction. It had been tried by several parties, each using up the thirty days allowed without success. But it would be hardly safe now to make such an offer to him (Mr. Hobbs). He had sold but few of those locks in England. He was sent for to the Bank of England, and believed that he was going to accomplish something great at that place, but found that the price named, fifty guineas, was esteemed perfectly frightful. He was told that it would never do to name such a price to the Directors. Mr. Hobbs told the gentleman that he could furnish a very good lock for twenty guineas—it would be the same one, by the way! He was exposing no trick of the trade in confessing that which was already well known, not only in the sale of locks, but in many other branches of business. He sold the Bank of England a lock, and supposed it would pave the way to a very extensive introduction, but it did not. In America, every bank in the country which had a capital of \$100,000 justly estimated \$250 a small consideration for a suitable lock, but in England twenty and thirty guineas was the highest practicable price.

Picking the Bramah lock he esteemed his greatest performance. This lock hung in a window in Picadilly with a challenge of 200 guineas appended in large letters, and he had been weak enough to make a small bet before leaving America, that he would bring home the guineas, or at all events would open the lock. He succeeded in doing both. But the difficulties were far greater than with the famous 16-tumbler Chubb lock in the Exhibition. Bramah's had 18 tumblers or

equivalent slides, all radiating from a centre. The key was a conical stem with delicate grooves on its exterior, and slid into a key-hole which was only a quarter of an inch in diameter. This latter was the whole space through which to introduce instruments. Considerable effort was required to bring the parties actually to the sticking point. The challenge was a specious one; it read as follows: "The artist who produces an instrument which will pick this lock, shall receive 200 guineas the moment the same is produced." It looked bold, but really meant very nearly nothing at all. When the trial was finally agreed on, the lock was bolted on a mass of wood and he was allowed to go to work. A spring, usually but slight, was used to resist the entrance of the key, but in this lock that spring required a force of fourteen pounds to urge it back. The key-hole, though small, allowed a screw to be put in which forced back the spring and held it. After nearly eighty hours' measuring and preparation, Mr. Hobbs succeeded in opening the lock, and then successively locked and opened it three times in an hour in the presence of the umpires agreed on. The triumph came near being fruitless, however, in consequence of an unexpected and apparently very slight circumstance. It was conditioned that the lock should be readily opened by the proper key—the old key—when the operation was completed. This was to test the success of the operation in not destroying or injuring any of the works. When Mr. Hobbs' work was finished and his tools removed, one of the umpires, a very good mechanic, took the key and advanced to the lock to open it, Mr. Hobbs and the other gentlemen, of course, standing back. He applied the key and attempted to turn it without effect. Mr. Hobbs wished to show him how, but was forbidden, and for a moment the prospect looked blank. The umpires, however, decided that he should be allowed to make, standing in his place and in the hearing of all parties, such directions as he saw fit, and they would then decide whether the instructions were legitimate or not. He told him to press in the key further, because the resisting spring was unusually stiff. With this explanation the lock was immediately opened.

The arbiters were called away to Paris on another matter, and the payment was then declined by the Bramah parties on the ground that the challenge attached to the lock in the window was the only one ever formally made by them, and no single "instrument" "produced" by any "artist" had opened the lock. On the return of the umpires they pronounced this excuse frivolous, and the gold was paid. Mr. Hobbs said that he had, perhaps rather weakly, allowed the gold to be exhibited with a descriptive label in the Exhibition, and the only slash he had received from any of the London journals, which hit him hard, was one from the *News* the next morning, in which it was remarked that the triumph would have been complete except for the fact that the victor, in true Barnum style, had exhibited the gold.

Mr. Hobbs told an amusing story of opening a very elaborate French lock, on the letter or dial principle, and changing the combination while the exhibitor's attention was diverted by his friend, and then asking the exhibitor how it worked; first compelling him to a very

petulant exhibition of slight irritable qualities, and finally to an elaborate rehearsal of all the expletives in both the French and English languages, when he found that he could not open his lock himself, while Mr. Hobbs could. The exhibitor subsequently watched his lock very carefully. Mr. Hobbs said that was the best way to make many of the "ingenious" locks secure.

The warded lock was of Roman origin. The movable tumblers were of Egyptian origin. The letter lock, or dial lock without key, was first introduced, Mr. Hobbs thought, by Regnier of Paris, about 1762.

Mr. William H. Butler, of the firm of Valentine & Butler, being called upon, said that powder had done away with the open key-hole, and had introduced a great change in locks during the last two years. He thought blowing up locks and safes with powder, was more practised in this country than in England, perhaps in consequence of the absence of as efficient watchmen here. Even five and ten dollar locks must be made powder-proof now, or they would not sell in this country. One of the great advantages of the dial lock lay in the fact that no possible space existed for the introduction of powder. He believed that, ten years hence, no safe with a key-hole would be tolerated where any inducement existed for burglars.

Dr. Rich asked if gunpowder always or generally *opened the safe*, and whether it might not frequently, by deranging and bending the parts, make the bolt more immovable than before.

Mr. Butler said it generally opened the works so effectually that the contents of the safe were very easily made available. A very common way, and one which unfortunately would seem to be as effective against the dial lock as any other, was to drill a hole through the exterior, either of the lock or of some adjacent portion of the door, and deposit the powder in the cavity thus made accessible. Pieces of the doors of safes had been thrown in some instances upon the tops of adjacent buildings.

Mr. Stetson asked if, under such circumstances, the burglars usually obtained possession of the valuable contents of the safe before the alarm brought others to the spot.

Mr. Butler said the noise was very greatly deadened by stopping the windows and outlets of the building, and covering the safe with bagging and like deadening material. The robber usually remained concealed until he found no alarm was raised, and then quietly removed the money and withdrew.

The subject of cheap locks was introduced, and the lock of Mr. McWilliams again exhibited. Mr. Hobbs agreed with Mr. Butler that this was a very ordinary lock and very easily picked, but like many others of less pretensions, was a good cheap lock. The street door lock of Valentine & Butler was alluded to by several members as one which was operated by a very small key. The key is a thin plate of metal properly notched at the end, and is incapable of turning, but produces its effect by direct pressure against the tumblers. Mr. Butler thought several tons of metal were toted about the city at the present moment needlessly, in the form of heavy keys in the pockets of

our citizens. Mr. Hobbs did not believe that this or any lock with three or four tumblers with false notches, *would* be picked by burglars on a street door.

Allusion was made by Mr. McWilliams, Dr. Rowell, and others, to a lock which was operated differently on the inside from the outside by the same key, and which was highly useful on the rooms of hotels. The guest, on leaving his room and locking the door from the outside, left it in such a condition as to be very easily opened by the chambermaid, but on retiring and locking it on the inside, no skill yet known, even of the most accomplished burglar, could open it from the outside.

## PROCEEDINGS OF THE BRITISH ASSOCIATION.

From the London Athenæum, Oct. 1862.

### *Section G.—Mechanical Science.*

The Secretary read a paper by Mr. C. Atherton, late Engineer of the Royal Dockyard, Woolwich, "On Unsinkable Ships." The author pointed out the importance of having ships made of a material of less specific gravity than water; so that, whatever injury the ship may sustain so as to admit water, they would never sink, and thus both crew and ammunition or treasure might be saved. He considered such a build would be very valuable for small vessels, which could enter where the large armor-plated ships would be stopped. The idea, he thought, was worthy of consideration.

Dr. Fairbairn, the President of the Section, read a paper "On the Results of Some Experiments on the Mechanical Properties of Projectiles." He commenced by stating that, in the investigations which had taken place with regard to projectiles and armor-plated ships, one great difficulty that had arisen was to get good plates of sufficient thickness, and vessels of sufficient tonnage to carry those plates. It appeared that they were limited to plates of 5 ins. in thickness; with plates heavier than that, a ship would not be what was technically called "lively." He had attended the experiments at Shoeburyness from the commencement, and they had reference to the force of impact. He would state the results of the more recent experiments, which had not yet been published. The first series of experiments had reference to the quality of the plates and the properties of the iron best calculated to resist impact. There were three qualities required: first, that the iron should not be crystalline; but secondly, that it should be of great tenacity and ductility; and thirdly, that it should be very fibrous. The mean statical resistance to crushing of the two flat-ended specimens of cast iron is 55.32 tons per square inch. The mean resistance of the two round-ended specimens is 26.87 tons per square inch. The ratio of resistance, therefore, of short columns of cast iron with two flat ends to that of columns with one flat and one round end is as 55.32 to 26.87, or as 2.05 to 1—an extremely close confirmation of Prof. Hodgkinson's law. Applying this same rule to



the steel specimens, it would appear that the flat-ended shot should have sustained a pressure of 180 tons per square inch before fracture. In the experiment it actually sustained 120 tons per square inch without injury, excepting a small permanent set. In the experiments with cast iron, the mean compression per unit of length of the flat-ended specimens was  $\cdot 0665$ , and of the round-ended  $\cdot 1305$ . The ratio of the compression of the round-ended to the flat-ended shot was, therefore, as  $1\cdot 96:1$ , or nearly in the inversed ratio of the statical crushing pressures. Applying this law to the case of the steel flat-ended specimen, it may be concluded that the compression before fracture would have been only  $\cdot 058$  per unit of length. The determination of the statical crushing pressure of the flat-ended steel shot as 180 tons per square inch and its compression as  $\cdot 058$  is important, on account of the extensive employment of shot of this material, size, and form in the experiments at Shoeburyness. In the case of the lead specimens, the compression with equal weights was the same whether the specimen were at first round-ended or flat-ended. This is accounted for by the extreme ductility of the metal and the great amount of compression sustained. In regard to the wrought iron specimens, it may be observed that no definite result is arrived at, except the enormous statical pressure they sustain, equivalent to 78 tons per square inch of sectional area, and the large permanent set they then exhibit:—

	Statical Resistance in Tons per Square Inch.	Dynamical Resistance in Foot lb. per Square Inch.
Cast iron, flat-ended, . . .	55 32 . . .	776 8
Cast iron, round-ended, . . .	26 87 . . .	821 9
Steel, round-ended, . . .	90 46 . . .	2515 0

In the experiments on the wrought iron specimens, the flat-ended steel specimens, and the lead specimens, no definite termination was arrived at, the material being more or less compressed without any fracture ensuing. The mean resistance of the specimens of cast iron is 800 foot pound per square inch; that of the specimen of steel is 2515, or rather more than three times as much. The conditions which would appear to be desirable in projectiles, in order that the greatest amount of work may be expended on the armor-plate, are—1. Very high statical resistance to rupture by compression. In this respect, wrought iron and steel are both superior to cast iron; in fact, the statical resistance of steel is more than three times, and that of wrought iron more than two and a half times that of cast iron. Lead is inferior to all the other materials experimented on. 2. Resistance to change of form under great pressure. In this respect hardened steel is superior to wrought iron. Cast iron is inferior to both. The shot which would effect the greatest damage to a plate would be one of adamant, incapable of change of form. Such a shot would yield up the whole of its *vis viva* to the plate struck; and, so far as experiment yet proves, those projectiles which approach nearest to this condition are the most effective. The President stated that steel shots might be made at a comparatively small cost. M. Bessemer had told him, that

if he had a large order he could produce steel shots at a little more than the price of iron; but if the ingots as cast had to be rolled or hammered to give them fibre, they would cost near £30 a ton, instead of £8 or £10 per ton.

Mr. J. Nasmyth inquired whether chilled cast iron flat-headed shot had been tried? The process of chilling cast iron was very simple and inexpensive. If chilled flat-ended cast iron shot had not been tried, it was very desirable it should be.—Dr. Fairbairn said they had not been tried; but he believed that shot thus made being hardened to a certain depth, having its velocity the same, would in striking the object break as if it had not been hardened at all. However, he would have experiments made; and he hoped that before the next meeting of the Association the matter would be proved experimentally.

Mr. T. Aston read a paper "On Projectiles with regard to their Power of Penetration." After alluding to the interest with which the contest between artillery and armor-plates has been watched by the country, he explained what was the actual condition of this important question so late as May last, by quoting statements which had been made in Parliament and elsewhere, that after all the vast expenditure upon our new artillery, the navy of England is compelled to arm herself with the old smooth-bore; and that is the best gun the navy actually possesses, though admitted to be so inefficient. Such being the state of the question a few months ago, Mr. Aston proceeded to consider, first, the reason why the artillery hitherto employed in the service (including rifled guns and smooth-bores) has always failed to make any impression on the plated defences at ordinary fighting range; and, secondly, by what means artillery science has lately reconquered its lost ground. Three conditions were laid down as necessary to enable artillery to attack successfully armor-plate defences:—1st, the projectile must be of the proper form; 2d, of the proper material; and, 3d, be propelled from a gun able to give it the necessary velocity. The artillery of the Ordnance Committee failed because they utterly neglected the first two conditions, and had recourse to the brute force of the smooth-bore for the third. The expression accepted as representing the penetrating power of shot was "velocity squared multiplied by weight;" but the form of the shot and the material were conditions altogether omitted from the expression; and the importance of the omission will be obvious at once if an analogous case—say a punching machine employed to perforate wrought iron plates—be taken. What would be the result if the punch which is made of suitable shape and material were removed, and a round-headed poker of brittle cast iron or soft wrought iron were substituted in its place? The great importance of velocity was conceded at once—it is a *sine qua non* condition; but there has been great misconception in supposing that the old smooth-bore gives a greater initial velocity than the rifled gun, as the results obtained would show. The average initial velocity of the 68-pounder is, in round numbers, 1600 feet per second, with a charge of powder one-third the weight of the shot, the length of the shot being, of course, one calibre. Sir W. Armstrong stated, that with a charge

of powder one-quarter the weight of the shot, he obtained with his rifled gun an initial velocity of 1740 feet per second. He did not state the length of his projectile. Mr. Whitworth, with a projectile two calibres long, obtains an initial velocity of 1900 feet per second; and with a projectile one calibre long, like that of the smooth-bore, an initial velocity of 2300 feet per second; being greater than that of the smooth bore in the proportion of 23 to 16. The following table shows the actual results obtained by various guns:—

Gun.	Range.	Projectile.	Powder Charge.	Penetration into Armor-Plate.
Armstrong 110- pounder, }	200	110 lb. solid.	14 lb	1½ to 2 inches.
68 pounder smooth-bore, }	200	68 lb. solid.	16 lb.	2¼ to 3 inches.
Whitworth 70- pounder, }	200 {	70-lb. shot and shell.	{ 12 lb.	{ Through plate and backing.
Whitworth 120- pounder, }	600	130-lb. shell.	25 lb.	{ Through plate and backing.

The first two results show that the Armstrong rifled gun is a worse compromise than the old gun it was intended to supersede. It is worthy of notice, that the velocity of the Whitworth heavy projectile, after traversing 600 yards (a good fighting range), was 1260 feet; being 50 feet greater than the initial velocity of the Armstrong projectile, which is 1210 feet at the muzzle of the gun. The total results in respect of penetration being so decidedly in favor of Whitworth, it follows that he has adopted the best compromise, by combining all three necessary conditions of proper form and material of projectile and sufficient velocity. That the velocity, though perhaps at the muzzle of the gun slightly below that of the smooth-bore, is sufficient when combined with proper form and material of projectile, is shown by the penetration result, which in the case of the Whitworth is through and through both armor-plate and backing; in the case of the smooth-bore is barely through half the armor-plate; and in the Armstrong is not half through. The form of projectiles, both shot and shell, employed by Mr. Whitworth for penetrating armor-plates, was then described. The material of which the projectile is composed is what is termed homogeneous iron—combining the toughness of copper with the hardness of steel. It undergoes a carefully regulated process of annealing. The same metal is used for the Whitworth field guns; and practical improvements now enable it to be worked in masses of any requisite size, whose quality may be henceforth depended upon with certainty. Mr. Whitworth is therefore now making his heavy ordnance with both interior tubes and outer hoops of homogeneous metal of the improved manufacture; so that the guns will be constructed throughout of one uniform metal, without any welding at all. Experience justifies the

expectation that they will be free from the objections which it is well known are inherent in all welded guns, and be fully able to resist the severe and searching strain that is sure sooner or later to disable a gun built up of forged coiled tubes, if it be called upon to do its full work by discharging heavy projectiles at efficient velocities.

Mr. Nasmyth said the steam-ram was an old subject with him. A plan was proposed by him to the Admiralty so long ago as 1845. He thought the more destructive you can make the attack on your adversary the better. It was not right to be torturing your enemy by drilling numerous small holes in him: it was like taking a whole day to draw a tooth. His idea was to make one large hole and sink the ship at once with the enemy. It was a question of momentum. The first practical ram was the *Merrimac*; but the Southerners made a mistake in giving her a sharp end: it should be blunt; and such was the original plan of the author, nor had he seen any reason to alter his views. The vessel must present as low an angle as possible to turn shot; but she must also have strength in the direction of her length, and use the utmost possible amount of steam to get velocity; and, to meet the objection that the impact might destroy the engines, which he did not anticipate, he would place the engines on a slide, with buffer arrangements. With such a vessel he would dash into the *Warrior* as into a handbox. The plates would be crushed at once. He hoped the Admiralty would devote a thousand pounds or two to try the effect of a ram against some old hulk, then the *Trusty* with armor-plates, and afterwards against the *Warrior* herself; and he thought it would be best to knock a hole in her ourselves, in preference to having it done by an enemy.—Mr. Webster hoped that in the discussion they would not omit the question, brought before the Section by Mr. Atherton, of unsinkable ships. It was quite clear from the late experiments that ships could not withstand the attack of guns, and there was a reason why we should give some attention to other matters of ship architecture than the mere attempting to defend them by armor-plates against shot.—Admiral Sir E. Belcher observed that in 1818 he had urged a plan of unsinkable ships to Sir Robert Seppings by shutting down the hatches and using the pumps to pump in air: but this was objected to, on the ground that it was necessary to have an opening to keep the timber sound. He advised water-tanks as a backing to the sides of ships, believing that such an arrangement would withstand even Mr. Nasmyth's ram.—Mr. R. W. Woolcombe explained the nature of his projectile, by means of which he got rid of the friction caused by rifling, with no more windage, the projectile being a disk traveling in a direction perpendicular to its axis of rotation.—Mr. G. P. Bidder, Jr., observed that with a smooth-bore the balls go accurately for a short distance, but afterwards they diverge in uncertain directions; and this he showed must be the case as well with Mr. Woolcombe's shot as with an ordinary smooth-bore shot.—Captain Blakeley said that Mr. Aston had told them that Mr. Whitworth was beginning to use homogeneous metal for the inside and the outside of his guns; and he (Capt. Blakeley) would encourage him to use this, as he had for several years past

used it with great advantage. He had made guns, in use abroad, of large size, which would throw rifle 600-pound shot with 80 pounds of powder. The Spaniards had such guns; and he thought the English Government ought to give some encouragement for trials of every kind of gun as well as rams.—Mr. J. Scott Russell said at the last meeting it was ascertained that  $4\frac{1}{2}$ -inch plates and 18-inch of wood would beat the gun: but the late experiments had shown that we have no navy if you keep wooden ships with iron plates. Sir W. Armstrong fired our wooden ships, and Mr. Whitworth had proved that he can do the same if the ship be plated. No ship of ordinary size was big enough to carry indestructible plates. Why could not a good fighting ship be made which should keep out a shell? He believed that Whitworth's shell would be stopped by double armor-plates, one in front and the other behind it; but a larger one, it was said, would be made which would destroy any thickness of double plates; and he believed it would be done. There was one way of carrying increased thickness, namely, by the increased size of vessel. There was, however, another way without increasing the size—to build the ship up but little beyond the water's edge; cover her below the water-line as far as was necessary to prevent penetration; then diminish the battery on the deck; and then they would have a vessel somewhat like the *Monitor*, absolutely shot-proof. Capt. Coles' ship was, he believed, on that principle.—Dr. Robinson had lived long enough to learn that such prefixes as "im" and "un" were very unsafe syllables to deal with, whether as applied to unsinkable ships or the impossibility of making shot-proof ships. He thought, however, that the materials for unsinkable ships would have no power of resistance. He wished to know as to the price of a gun of the homogeneous metal as compared with one on the Armstrong principle.—Mr. Aston said that the price of homogeneous metal was gradually being lowered, and that the Whitworth gun could be produced at a lower price than the Armstrong.—Dr. Robinson, in continuation, observed that such was the arrangement of the Whitworth gun, that the friction in the barrel was reduced to a minimum. The shot would fall from the barrel with a very small inclination. He thought that Mr. Woolcombe's shot promised advantages in some respects, but he pointed out great disadvantages.—Mr. Aston asked what would be the condition of Mr. Scott Russell's ship with shells which would penetrate 30 feet below the water-line? and this, Dr. Robinson had told them, was possible. As to the partially defended ship, would any captain ask his men, some to stay in the undefended part, while others were comfortably ensconced behind 8 inches of armor-plate? He (Mr. Aston) considered that guns built of rings could never stand.—The President said the great difficulty about homogeneous iron was its liability to be of unequal quality. Mr. Whitworth took very great pains in the manufacture, and the great danger in the case of the coils is that they are apt to elongate.

A short discussion then took place on Mr. Thorold's paper "On the Failure of the Sluice in the Fens, and the Means of Securing such Sluices against a similar Contingency."

(To be Continued.)

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, Feb. 19, 1863.*

John C. Cresson, President, in the Chair.

John Agnew, Vice President.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, the Royal Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; Major L. A. Huguet-Latour, the Natural History Society, Montreal, and the Canadian Institute, Toronto, Canada; Capt. Wm. H. Swift, Boston, Mass.; B. H. Latrobe, Esq., and the Maryland Institute, Baltimore, Md.; A. D. Bache, LL.D., and Frederick Emmerick, Esq., Washington, D. C.; the American Philosophical Society, Charles J. Gobrecht, Esq., Isaac S. Cassin, Esq., Professor John F. Frazer, and Professor John C. Cresson, Philadelphia.

Donation to the Cabinet from the heirs of Frederick Haas, late of Germantown, Penna., through Joseph Haas, Esq.—a Stocking Machine imported by the early settlers of Germantown; now in complete working order.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of January was read.

The Board of Managers and Standing Committees reported their minutes.

The Board of Managers reported that they have organized for the present year by electing Mr. William Harris, Chairman, and Messrs. Isaac S. Williams and Wm. A. Drown, Curators; and appointing the following Standing Committees:—

*On Publications.*

John C. Cresson,  
B. H. Bartol.  
Fairman Rogers,  
Washington Jones,  
Robert Briggs.

*On Instruction.*

John F. Frazer,  
Frederick Fraley,  
Isaac B. Garrigues,  
Alan Wood,  
George Erety.

*Managers of Sinking Fund and Finance.*

Frederick Fraley,  
Samuel V. Merrick,  
Evans Rogers,  
John F. Frazer,  
George Erety,  
Jacob Naylor.

The Standing Committees for the ensuing year were appointed by the President, and approved, as follows:—

*On the Library.*

Henry Ames,  
James H. Cresson,  
George M. Conarroe,  
George Erety,  
John Ferguson,  
Henry D. Gregory,  
Raper Hoskins,  
Jas. T. Lukens,  
H. G. Leisenring,  
G. L. Martindale.

*On Cabinet of Models.*

James Agnew.  
Wm. B. Bement,  
James Fraiser,  
Mordecai W. Haines,  
John Horton,  
John Kile,  
Wm. B. Le Van,  
Thos. H. McCollin,  
John L. Perkins,  
Coleman Sellers.

*On Exhibitions.*

John E. Addicks,  
John Agnew,  
James H. Bryson,  
James H. Cresson,  
William A. Drown,  
Edwin Greble,  
John Gardiner, Jr.,  
William Harris,  
Jacob Naylor,  
Thos. S. Stewart.

*On Cabinet of Arts and  
Manufactures.*

Jas. C. Booth,  
Thos. Bickerton,  
Henry Bower,  
Chas. G. Crane,  
David M. Hogan,  
Joseph Klapp,  
C. Eugene Meyer,  
S. G. Rosengarten,  
Eliashib Tracy,  
Wm. Weightman.

*On Cabinet of Minerals and  
Geological Specimens.*

Robert Bridges,  
Isaac H. Conrad,  
John F. Frazer,  
Emile Geyelin,  
Isaac B. Garrigues,  
Henry Hartshorne,  
B. Howard Rand,  
Robert E. Rogers,  
Richard A. Tilghman,  
John C. Trautwine.

*On Meetings.*

Thos. M. Adams,  
Wm. H. Brown,  
George Burnham,  
Chas. S. Close,  
James Dougherty,  
Henry Howson,  
Washington Jones,  
Edward Longstreth,  
Percival Roberts,  
M. P. Simons.

*On Meteorology.*

Charles T. Adams,  
Charles M. Cresson,  
Thos. M. Drysdale,  
John F. Frazer,  
James A. Kirkpatrick,

James A. Meigs,  
Benjamin V. Marsh,  
Fairman Rogers,  
James S. Whitney,  
Thos. J. Weygandt.

E. G. Chormann's Improved Stereoscopic Instrument was exhibited. It consists of an outer and an inner casing, and a frame; the inner casing sliding within the outer one. To the front edge of the frame, which slides into the inner casing, is hinged two arms, each of which is provided with a ring for holding a lens. When the instrument is to be used, the frame is drawn from the inner casing as far as possible, without entirely removing it therefrom, and the arms turned out so as to be at right angles to the frame. The picture being secured to the outer case by a flat spring, which holds it against the same. The glasses may be applied to the eye as in the ordinary Stereoscope, and the adjustment made by sliding the inner case back and forth within the outer one, until the proper focus is obtained. When not required for use, the arms holding the lenses may be folded together within the frame, and the latter pushed into the casing; the whole being thus condensed into a compact form of such dimensions as to be contained within the vest-pocket without inconvenience to the wearer.

Mr. Thomas Shaw exhibited a specimen of Fractured Glass Tube, the peculiarity of which consists in the line of fracture, which is in the strongest direction, and instantaneous throughout the whole length (from 10 to 15 feet), without any apparent cause. This does not occur with tubes made in shorter lengths, other conditions being the same. He attributes the cause to the mode of straightening the tube, which is done in this wise. After the tube is drawn out sufficiently, it is held suspended in the air, and revolved until sufficiently cool to permit no further bending. It will be observed that this continual bending, which the above operation causes, must necessarily bring the glass to a state of *torsion* in the direction of the fracture. He has since had tubes made of the same length, in the usual manner, with the exception of cooling and straightening them upon a flat surface, that are free from this evil.

*A Comparison of some of the Meteorological Phenomena of JAN., 1863, with those of JAN., 1862, and of the same month for TWELVE years, at Philadelphia, Pa.*  
 Barometer 60 feet above mean tide in the Delaware River. Latitude  $39^{\circ} 57\frac{1}{2}'$  N.; Longitude  $75^{\circ} 10\frac{1}{2}'$  W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	January, 1863.	January, 1862.	January, 12 Years.
Thermometer—Highest—degree,	61.00°	54.00°	62.00°
“ “ date, . . .	15th.	1st.	7, '55; 11, '58.
“ Warmest day—Mean,	58.33	43.8	57.3
“ “ Date,	15th.	1st.	11th, 1858.
“ Lowest, degree, . .	14.00	10.0	— 5.5
“ “ date, . . .	18th.	5th.	23d, 1857.
“ Coldest day—Mean,	20.67	18.80	— 1.0
“ “ date,	18th.	5th.	9th, 1856.
“ Mean daily oscillation,	12.90	10.21	11.79
“ “ range,	5.60	5.04	6.54
“ Means at 7 A. M., .	33.95	29.36	28.01
“ “ 2 P. M., . . .	40.95	34.47	35.53
“ “ 9 P. M., . . .	36.64	31.97	31.39
“ “ for the Month,	37.18	31.93	31.64
Barometer—Highest—Inches, .	30.571 in.	30.408 in.	29.704 in.
“ “ date, . . .	18th.	14th.	28th, 1853.
“ Greatest mean daily press.,	30.553	30.400	30.609
“ “ date, . . .	18th.	14th.	28th, 1853.
“ Lowest—Inches, . . .	29.127	29.325	28.911
“ “ date, . . .	16th.	1st.	23d, 1853.
“ Least mean daily pressure,	29.293	29.472	29.086
“ “ date, . . .	16th.	1st.	23d, 1853.
“ Mean daily range, . . .	0.266	0.261	0.217
“ Means at 7 A. M., . .	29.925	29.942	29.971
“ “ 2 P. M., . . .	29.867	29.894	29.931
“ “ 9 P. M., . . .	29.905	29.931	29.957
“ “ for the Month,	29.899	29.922	29.953
Force of Vapor—Greatest—Inches,	0.462 in.	0.275 in.	0.505 in.
“ “ “ date, . . .	16th.	12th.	11th, 1858.
“ “ Least—Inches,	0.057	0.051	0.023
“ “ “ date, . . .	18th.	4th.	22d, 1857.
“ “ Means at 7 A. M., .	0.166	0.134	0.136
“ “ “ 2 P. M., . . .	0.175	0.145	0.154
“ “ “ 9 P. M., . . .	0.172	0.142	0.147
“ “ “ for the month,	0.171	0.140	0.146
Relative Humidity—Greatest per cent.,	100 per ct.	100 per ct.	100 per ct.
“ “ “ date, . . .	21st.	29th.	Often.
“ “ Least per cent, . .	38.	32.0	24.0
“ “ “ date, . . .	2d and 3d.	26th.	25th, 1860.
“ “ Means at 7 A. M., .	78.0	80.0	80.2
“ “ “ 2 P. M., . . .	65.3	70.7	69.0
“ “ “ 9 P. M., . . .	74.8	75.4	77.0
“ “ “ for the month,	72.7	75.4	75.4
Clouds—Number of Clear days,* .	7	5	8.6
“ “ Cloudy days, . . .	24	26	22.4
“ Means of sky cov'd at 7 A. M.,	68.1 per ct.	74.8 per ct.	63.6 per ct
“ “ “ “ 2 P. M., . .	70.0	73.5	63.6
“ “ “ “ 9 P. M., . .	60.6	73.9	49.1
“ “ “ “ for the month,	66.2	74.1	58.8
Rain and melted Snow—Amount .	4.698 in.	4.500 in.	3.351 in.
No. of days on which Rain or Snow fell,	14.	16.	10.7
Prevailing Winds, . . .	N.50°26'W. 175	N.18°26'W. 335	N.59°35'W. 320

\* Less than one-third covered at the hours of observation.



JOURNAL  
OF  
THE FRANKLIN INSTITUTE  
OF THE STATE OF PENNSYLVANIA,  
FOR THE  
PROMOTION OF THE MECHANIC ARTS.

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APRIL, 1863.

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CIVIL ENGINEERING.

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For the Journal of the Franklin Institute.

*Papers on Hydraulic Engineering.* By SAMUEL McELROY, C. E.  
PUMPING ENGINES, No. 3.—(Continued.)  
(Continued from page 13.)

BOILERS.—Having referred to *Pumps* and *Engines*, the third subdivision of our subject brings us to the discussion of the generators of power in the boiler room.

Of the three leading classes of boilers, stationary, marine, and locomotive, the latter has maintained its original type with much greater uniformity than the others, which show, as we also see in the case of pumps and engines, a strange diversity of opinion developed in numerous varieties of form.

Aboard ship and ashore, the simple process of water evaporation has been attained with the most varied forms of boilers, which would occupy a long list in the mere enumeration. As to the wagon shape, dome shape, and circular shells, with chambers, passages, water spaces, flues and tubes, spiral, upper returned, lower returned, double returned, vertical, inclined, and horizontal, in either steam or water conduits, our text books are full of examples, which go very far to show how much a simple process may be overlooked or overburthened in the zeal of invention or the fever of mechanical transpositions; and the practical comment experience has made on the greater part of all these devices is, that they fail to yield a reason-

able per centage of useful effect, and come far short, as a rule, of the natural law of evaporation.

The first requisite of a boiler is, that it should yield the greatest possible useful effect from its fuel combustion; the second requisite covers certain details of strength, durability, tightness, ease of access and repair, and compactness of form. These requisites should control the construction of boilers, and involve the general discussion of their operation and proportions; a discussion which may properly be directed to the *furnaces, interior form, exterior form, and appurtenances*, and some peculiarities of management.

*Furnaces.*—Chemistry demonstrates in clear and unequivocal language, that the process of fuel combustion is controlled by certain laws of combination, which must be carefully observed to attain maximum results. Without pausing here to quote the basis of the scientific theories on this subject, their lessons may be briefly summed up in the statement that the chemical union of the carbon and hydrogen of the furnace with the oxygen of the atmosphere, requires about 150 cubic feet, or 11.48 pounds of air for the perfect combustion of one pound of coal; and that from the difference between chemical *mixture* and chemical *unity*, combustion will be imperfect through the production of carbonic oxide in place of carbonic acid gas, and otherwise, if this *unity* is prevented. In how many boiler shops of the country is it understood, that practically the coal which goes upon the grates is the mere base of combustion, bearing a proportion of only one-thirteenth or one-fourteenth to the real agent, and that the vitality of each boiler depends on the length, breadth, and depth of the furnaces, and the supply of air through the ash-pits, grates, and other inlets, which may or may not be provided? The self-styled “practical” man believes that his boiler is made to burn coal; the engineer understands that it really burns air, and loses in efficiency by the per centage of air it fails to consume.

The subject of air supply to furnaces has been carefully investigated by numerous experiments in England, which, while more particularly directed to the prevention of smoke, have also made it plain that the ordinary grate openings are insufficient, and the surplus may be beneficially introduced in the furnace or the flue contiguous to it, provided the “mechanical mixture of the air and gas be continuously effected, before the temperature of the carbon of the gas (then in a state of flame) be reduced below ignition.”\* The investigations of Messrs. Prideaux, Clarke, Williams, and various other experimenters, confirm very fully what is theoretically obvious as to the ordinary grate opening, while the experiments with locomotive fire-boxes, both in England and this country, also demonstrate clearly the benefit of air supply above the grates, and directed towards the coal, rather than through it.

In many of the marine boilers recently built for the naval steamers, and some of our stationary boilers in water-works, as at Hartford and Brooklyn, and other instances, the fire doors have the inner plate

\* C. W. Williams on Combustion of Coal, p. 89.

perforated with numerous small holes, which may be used or not, as a valve in the outer plate is regulated. This accomplishes the object to a certain extent. Various devices, in the use of feeding tubes, hollow grate-bars, hollow stay-bolts, and other means of air supply have been tried on the North River steamboats, and otherwise, in some cases with very satisfactory improvements. All these steps of progress, under the guidance of natural laws, must eventually lead to good results, when the laws themselves are clearly comprehended and followed.

On the matter of furnace proportion, and other like proportions, the text books on the steam engine, as a class, pretend to lay down certain fixed rules, based on what is called "nominal horse power." This basis is one of the mechanical absurdities of the day, which is so entirely disconnected from actual horse power, and is itself so variable in its self-selected standards, that the common sense of the profession in this country rejects it, and defines the measure of actual work and capacity for work, as the only correct basis of calculation. Where we know that the combustion of coal may be raised from 3 to 20 pounds per square foot of grate per hour, and the steam pressure from zero to 60 pounds and over, in the same boiler, we also understand the folly of fixing its power by the size of the cylinder to which it may be attached, itself susceptible of great fluctuations in actual work.

There is, however, to each furnace, as to its connecting parts which form the entire boiler, a certain action of maximum useful effect, which involves the real problem of study and experiment, and has been too much overlooked in the ambition for novelty in form and patentability.

Of the several devices for automatic fuel-feed and cleaning, which have been invented and put in operation, however correct in principle, none have as yet offered a safe substitute for the ordinary manual attendance; and for the present our boiler furnaces should be adapted to the conditions of this attendance.

We may say then, from considerable observation of actual results, that the ordinary length given to our furnaces of  $5\frac{1}{2}$ , 6, and  $6\frac{1}{2}$  feet, is entirely too great for careful firing, and that in various experiments it has been found advantageous to brick up the lower end to about 5 feet. In this respect our experience has confirmed the rule of those English engineers who advocate smaller grate areas, and larger furnaces, the former, from the superior convenience of management, and the latter from the superior process of combustion. For similar convenience of management, comparatively narrow furnaces are advised, since the water spaces between them thus obtained, when made of proper width (in no case less than  $4\frac{1}{2}$  inches), form with their stud-bolts efficient sources of evaporation. It may also be taken as a rule, that the grates should be placed considerably below the flues, and not less than 30 inches below the crown sheet. Some remarkable improvements, from increase of bridge-wall, have been attained in special cases, and as to advantage in fire-box depth, every locomotive is a sufficient example, if the theory of combustion required further elucidation.

As to the strange varieties of grate-bars, which exist and occupy with their patterns rows of shelves in our pattern-rooms, it is enough to say that the bar should be narrow, with an upper groove to hold ashes for its protection from heat, deep in section, tapering to an edge, with liberal interspaces, and so bridged as to offer no hindrance to the use of the slice-bar or cinder-hook.

The use of thin, even fires, cannot be too strongly urged, from their effects on air supply and combustion. Four or five inches in depth give a careful fireman much less trouble than the barbarous masses of fuel too often seen in marine and stationary furnaces, and always improve a steam guage, while they reduce the coal account. We have reduced fires too often to put a steamer's boilers in racing order, not to have learned this experimentally, and there are abundant illustrations of the doctrine extant in our scientific treatises, if practice should seem to dispute it.

If fires are kept light, the corners carefully watched, the slice-bar judiciously used, and the supply regulated, the furnaces may be run for comparatively long periods in highly efficient state, without the wholesale cleaning expedient of "hauling" fires, which is objectionable in several respects, and more especially as to dirtiness and wastefulness.

It should be remembered also, in all cases of boiler design, that the furnace holds, in every boiler, an essential relation to the water evaporation; its fire surface, from the great intensity of its radiated and conducted heat, being by far the most effective in proportion to extent to any other heating surface. Aside, then, from this obvious propriety of a large combustion chamber, the question of heating surface dictates the use of roomy furnaces.

*Internal Form.*—Acting in connexion with the furnace or furnaces, by means of flues, tubes, and other conduits, the heated gases are conveyed in direct or broken lines to the chimney flue, or smoke stack, the aggregate length of travel, or amount of surface passed, differing materially in different types of boilers, each of which have, or have had, their warm advocates.

Although the object of each of the various forms or arrangements, internally as well as externally, has been to utilize most effectively the products of combustion in meeting the special objects of design, and in such cases as the locomotive boiler and others, certain special uses and requirements control the general design, it must be said of the various forms, as a whole, that they cannot all be correct in principle, or adequately fulfil the measure of their duty. It is true that different and local varieties of fuel may and should have some control over boiler design, as also in marine boilers the use of sea water and the want of space affect relative forms and positions, but above all special and local corrections, boiler construction and use ought to be regulated by general principles, applicable to the entire classes.

Looking upon the various forms of gas and steam passages and chambers, water spaces, and the like, as passing vagaries of construc-

tion, we may notice the relative claims of the more common and plainer internal forms, as to the question of flues and tubes.

We may take it for granted, also, that for greater advantage in strength, effective surface, and compactness of form, the flue boilers are to be preferred to the more primitive wagon-shaped and similar forms of boilers, which pertain to the days of ruder workmanship and more wasteful combustion, and have gone almost out of use.

The use, also, of the long, cylindrical, single flue boiler, seems to depend on certain habits or conveniences of use and construction, rather than any inherent advantage in form.

Notwithstanding the various arguments on the relative merits of slow or quick combustion, in which the Cornish and the Mississippi boilers are at strange antipodes of practice, it has been sufficiently demonstrated by observations we need not pause here to cite, that, except some slight allowances for differences in structure of coal, slow combustion is not economical, and that boilers of this type are not more economical than those of the marine or American type, of more compact form. We may assume, then, for the present, that the question of flues and tubes is important as pertaining to the general form demonstrated most efficient.

The transfer of the system of small horizontal tubes from the locomotive boiler, working with a steam blast, in which such tubes are matters of necessity, to marine and stationary boilers, operating under very different circumstances, appears to result from a desire to economize space; and the change of tube position to vertical lines, appears to result from a misconception of the action of vertical surfaces as steam generators. We say this with a reservation in favor of fire-engine boilers, or the Prosser boiler, and their class, which are expressly adapted to certain uses, or to superheating, or other collateral objects, having reference more generally to the recent patterns of marine and land boilers of multi-tubular form, which claim the advantages of large effective fire surfaces in reduced compass.

Taking any internal arrangement in consideration, it must be observed that by far the most active steam generator, with either flues or tubes, is the furnace surface. Experiment has shown, in locomotives, that two-thirds to three-quarters of the evaporation is produced at the fire-box, and observations on marine boilers (to which we may specially refer) tend to confirm this general statement.

It may also be said, that in reference generally to vertical surfaces as contrasted with the horizontal, vaporization depends on the quantity of heat taken from the plates, rather than that applied to them, and experiment confirms an inference deducible in theory, that the formation and slow discharge of steam bubbles on the former, prevents the free and proper return current of water, and interferes with surface efficiency. And, as to all classes of heating surface, efficiency is seriously controlled by the freedom of steam vent and of return water supply, as a modification of simple plate conduction of heat. From the use of vertical tubes or plates, two results then follow; first, that the generation of steam is hindered, from imperfect deli-

very of its globules, and, second, that the tubes are themselves liable to injury for want of adequate contact with the water, as a protective. Such fire surface cannot, therefore, be considered fully effective, and is not a correct measure of evaporative power.

In the group of horizontal tubes, the narrow water spaces and obstructed circulation for steam delivery and water return, also reduce the evaporative effect, and account for the rapid destruction of this part of the boiler, and its constant need of repairs. In fact, for both vertical and horizontal tubes, the chapter of repairs is sufficiently voluminous to justify a decided preference for more simple and accessible forms, afloat and ashore.

It is not only a matter of inference, that the plain upper arcs of horizontal flues of moderate size, with liberal water spaces, are more favorable to vaporization than groups of small and crowded tubes, while the avenues of passage for the heated gases from the furnace are also enlarged and improved, but it is a matter of experimental record in special cases, which further and more general experiment would undoubtedly confirm, that in actual evaporative results, flue boilers, judiciously arranged, exceed the multi-tubular. And they have, in addition, those advantages to which we referred in the outset, viz: strength, durability, tightness, ease of access and repair, with compactness of form.

*External Form.*—As connected with the internal arrangement of furnaces and flues, it may be taken as a rule, from advantages in steam generation and demand, from liability to priming, cost of boiler heating, equality of pressure, and other obvious reasons, that the water surface should be a minimum and the steam space a maximum. On this account in part, and also greater facility in construction, transportation, and bedding, strength of shells and braces, preference has generally been given to circular shells with steam domes, which elevate the supply steam pipe considerably above the water level, and when surrounding the uptake of the chimney, superheat their contents with most valuable effect.

As to proportionate length, in circular boilers with drop-return flues, and smoke flues below the shells, from experiments made on water works boilers with a high-range thermometer, which confirms the principle laid down by English authorities in other forms of boilers, we consider from three to three and a half times the diameter a liberal limit, which cannot be exceeded without detriment, and may admit considerable reduction.

In the drop-return boiler of the Hartford Water Works, which is conveniently accessible for temperature experiments, with a circular shell of 22.66 ft. length, a diameter of 7.5 ft., a furnace 7 ft. wide by 6 ft. deep, 4 upper flues of 18 ins. diameter by 14.33 ft. long, and 16 lower return flues, 13 of 8-inch, 2 of 9-inch, and 1 of 12-inch diameter by 12.25 feet long, the following temperatures were noted for an ordinary combustion of 6.4 pounds per square foot of grate, with a steam gauge of 25 pounds.

*Back Connexion.*

At upper flue end, . . . . .	550°
At middle flue end, . . . . .	400°
At lower flue end, . . . . .	370°
In the chamber, . . . . .	331°

*Return under the Boiler Shell.*

At under side of boiler, . . . . .	281°
At centre of passage, . . . . .	240°
At side of passage, . . . . .	209°
At floor of passage, . . . . .	160°

It was very evident from these results that the gases leaving the furnace at about 1900°, were retained too long within the boiler structure, which for a part of the flue travel was actually reducing the boiler temperature, at the ordinary and most convenient rate of combustion for the engine work. In this case, with the grates bricked over to an open area of about 23 square feet, and a total heating surface of 909 square feet, of which but 609 were calculated as effective, the proportion of heating to grate surface was  $909 \div 23 = 39.5$  to 1, the proportion of length to diameter being  $22.66 \div 7.5 = 3$  to 1. As will be observed in the table given in this paper, this boiler ranks high in vaporization, and with a more rapid combustion would of course modify and improve the temperature of its lower flues.

*Appurtenances.*—Each boiler should have an independent safety valve, feed valve, blow off valve, and steam stop valve, in order to control its action properly, and these should be proportioned to the limit of duty required in steam and water supply. In flue boilers, on the back connexions, a plug-hole should be made opposite each flue centre, for convenience in examination and cleaning. Manholes and handholes should be made for the same use.

In addition to the ordinary pressure gauge and water cocks, each boiler should also have a glass water gauge, the latter furnishing an important index to internal operations. For experimental observations on quality of coal and other notes of consequence, a feed tank is valuable, as an appurtenance to the boiler room, in which the exact supply may be measured, measurements of evaporation by tank being much more accurate than by volumes of steam.

Although the ordinary use of auxiliary steam pumps is objectionable on account of cost in steam, to every group of boilers such a pump is valuable for special service and particularly in connexion with pumping engine wells and force mains, to which they should be attached.

In boiler-feed, of course the supply should be taken from the hot-well, and where the feed pipe can be carried through the boiler connexion, some benefit may be derived from the heat imparted; but the use of small pipes, or coils of pipes, with abrupt turns, is to be avoided, as being much more expensive in friction than any apparent gain in temperature can compensate, the relative heat of feed water being less

important than is generally supposed, within the range of a few degrees.

The importance of bedding a boiler on cradles, is now commonly recognised, for convenience of access, inspection and repair to the lower shell, and the necessity of avoiding any strain from improper supports, is obvious.

From the important losses by radiation and leakage, perceptible or imperceptible, the value of careful covering by non-conductors may be strongly urged, as sources of increased efficiency and economy, and as regulators, to a certain extent, of evaporative action and tensile strain.

Tight and permanent floors, substantial walls and roofing for the boiler room, liberal working space for the firemen, selected firing tools, separate chambers for the coal and coal screens, metallic troughs for the hot cinders and ashes when hauled, and other like conveniences, not only promote the comfort of the attendants, but also advance that care of details, which always reduces the aggregate expense account where so much depends on manipulation and oversight. All such expenditures are admirable investments.

*Fuel.*—As between the use of wood and coal for combustion, the former, except for convenience in starting fires, bears no comparison in quality. Between bituminous and anthracite coal, experience in this country has established the superiority of the latter for stationary and marine uses, as to compactness and firmness of structure in the coal bunker and on the grate, specific gravity, cleanliness, steadiness of combustion, and general evaporative power. While there may be special varieties of the former, of great value when properly used, and with admirable constituents of quality, the white-ash anthracites as a class, are much more economical in quality, and such veins as those of the Scranton and Schuylkill valleys, take the front rank. And yet what is now generally admitted, was as generally denied a dozen years ago.

The theoretical value of one pound of coal, of good quality, as determined from its constituents of carbon and hydrogen, may vary from 13 to 15.5 pounds of water evaporated from 212°. As a general rule, among the complex stationary and marine boilers in use, not more than one-half this result is realized in practice, and sometimes not more than one-third.

Sewell (*Steam and Locomotion*, p. 99), refers to a range of results from 10.74 to 12.89 pounds, obtained by Cornish engineers in 1840 and 1846, and mentions other results of 13.48 pounds on an experimental boiler, 11.428 pounds from 212° from the combustion of 11,730 pounds of coal, at the Par Consols mine, while other instances of similar rates of practical evaporation on record in engineering works, furnish a severe comment on the enormous daily waste of fuel in our workshops and engine houses, and at sea.





*Duty Tests.*—In various experiments, recorded from time to time on pumping and other engines, it has been customary to bring the boilers up to their state of effective operation, and commence a set of parallel observations, at the close of which an attempt is made to leave them in precisely the initial state assumed. The objections to this process in all short experiments are important where close measurements of coal are needed, and have been discussed at length in former pages of this *Journal*, more particularly on page 239 of vol. xxxv., 1858, in which a different method is presented, by taking the boilers with fires hauled after being properly warmed up, and hauling fires at the close of the experiment to determine the value of the grate contents, in coal, cinder, and ashes, accounts being thus kept of all the fuel used from the time of starting the second fires.

*High Steam.*—It is well understood in the world of practical engineering, and is confirmed by correct theory, that it is much cheaper to make high steam than low steam, from the saving in fuel to produce equivalent power, the improved condition of heat convection in the boiler contents, the comparative losses by external radiation, and the resultant increase by superheating. The favorite method of “making up time” among first class locomotive engineers, by running up the steam gauge at the stations, and shortening the cut-off notch, illustrates forcibly the correctness of this source of economic increase of power, applicable to all kinds of boilers. It is a matter of demonstration, that 90·7 pounds of coal, making steam at 60 pounds, are worth 100 for steam at 15 pounds, or about atmospheric pressure, and that in each of the other sources of advantage named, the issue is decidedly favorable to the higher pressures. It is also true, that up to a certain range of heating, (550°,) iron boiler plates increase their strength, while below a certain tension, which is far within the limits of ultimate strain, a boiler is as safe from one pressure as another, in reference to the usual sources of danger from disruption and explosion, which rest so much on careful attendance. As to safety under working strain, we believe that there is little to be feared from steady pressure, even at ranges which may be called excessive, and have slept over 180 and 200 pounds of steam, after some study of the attention of the firemen to the gauge-cocks, confident of as great safety as over one-fifth or one-tenth the gauge. We do not, of course, advocate such a pressure for pumping engine boilers, but even in cases where a close throttle must be adopted, we certainly do advise something like the Cornish standard of pressure, from 45 to 60 pounds. The effect in duty, demonstrated by numerous trials on the Brooklyn boilers, of an increase from 9 to 18 pounds pressure, was too emphatic to leave any room for question, even as to so unreasonably low gauges.

*Superheating.*—Some positive means of giving all boiler steam the benefit of this process, should be adopted. Among all the extravagant claims of enthusiasts on this subject, which have induced a general re-action, too much has been proved as to its benefits to be lightly disregarded, up to a certain moderate range of application ;

and by this we mean an application more distinct and more clearly defined than the ordinary process of superheating common to boilers with chimney uptakes or steam domes. If saturated steam, by the addition of from 7 to 75 degrees of heat, will be expanded from 10 to 30 per cent., as some experiments have it, and such increment of heat can be conveniently taken from the wasted gases of combustion, there is great propriety in the application; and granting the special claim to be erroneous as to gain, if the steam can be fortified against the steam-pipe, chest, and cylinder radiations and condensations, so as to show the boiler pressure on the indicator cards, even this result is worth the slight cost of attaining it. In most of our engines, the losses between the cylinder and boilers are formidable in their per centage of coal waste.

*Improved Conduction.*—It is urged by some authorities and endorsed by experiment, that the use in boiler flues, of conducting pins about 3 ins. long, projecting downward, into the heated currents, by presenting much more favorable points of heat transmission than the smooth surface of the flue sheets, improves the evaporation. The application is simple and is justified by the conditions of furnace flue action.

*Summary.*—The general lesson taught by the diversified forms and operations of boilers, and the principles of their action is, that the great majority come far short of available natural results, from imperfect design and management, and that the simpler forms are practically and theoretically to be preferred.

In the table on page 225, and which is taken from various sources, rather as a general illustration of such results, than as collated evidences of any special theories, will be found with some study, a running comment on relative rates of combustion, relative grate and heating surface, relative efficiency of tubes and flues, and general proportions.

Its principal use, however, or the use of such a table as we should like to present, if present pressure of other occupations did not prevent, is to show the need of a more systematic investigation of a subject which is vital to all the mechanical operations of the day, and the general adoption of such rules of design and manipulation as shall improve the present wasteful experience. A single thought of the immense sums of money spent in fuel annually in our land, and the effect of even a moderate per centage of improvement, brings the necessity of some organized and effective movement in this direction forcibly to view.

Of this particular tabulation, however, it cannot be claimed that its special experiments have the force of absolute demonstration, since each is based on special and local conditions as to quality of fuel, manner of firing, correctness of coal account, rate of combustion, and other modifications which prevent a rigid deduction of any rule of proportion.

The most complete group of experiments on the "Michigan" made under the special charge of one of the most accomplished engineers of the day, and on boilers which are presented as perfections of multi-tubular model, are yet anomalous in their several results, and demon-

strate a fact practically known to all thorough-bred engineers, that with the same conditions of experiment results may be greatly varied by differences in manipulation. These experiments, made to determine a very different question, really became observations on relative facilities of combustion and evaporation in the same boilers.

The experiment on the "Susquehanna," as has been shown in a paper above referred to, were too carelessly made to secure correct results. Those on the "San Jacinto," made expressly to determine the relative merits of tubes and flues, just as expressly prove the value of results obtained under conditions of design and operation, clearly unfavorable to the latter.

While, then, a critical analysis of each experiment detailed, would modify its relations to the general aggregate, there can be no question, we think, that the aggregate itself is clear and plain on the advantages of simplicity in form, as to the desideratum of power, compactness, access, and other special requirements for boiler use, and the results obtained from the boiler of such construction are too prominent to be overlooked or denied.

There are several other points on this general subject which probably should be presented to complete the hurried sketch herein attempted, but cannot now be given from want of space and time.

(To be Continued.)

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### *International Exhibition.*

From the London Mechanics' Magazine, December, 1862.

CLASS X, SECTION A—JURORS' REPORT.

(Continued from p. 165.)

In the space beneath the caisson compressed air was used to expel the water to allow the men to work, and it was also employed to force down the cylinders to the requisite depth, the air pumps being worked by a steam engine from above. Within the caissons workmen were employed to remove the gravel, &c., from under the exterior edges as they descended, whilst the great mass of the material, which was cast by hand to the centre, was removed by means of the dredging apparatus worked by a steam engine upon the platform above. The novelty and the chief cause of the efficiency of this apparatus consisted in the centre cylinder being open to the atmosphere at the upper extremities, and plunged in the water at its lower end, by which means the great mass of the material could be removed by the dredging apparatus much more rapidly and economically than if all the material had been hoisted in buckets through the air-locks, in the usual closed cylinders. The caissons were thus carried down to the requisite depth below the ordinary level of the Rhine most successfully, in a much shorter time, and at infinitely less cost than by the usual method, and the piers were founded at such a depth below the scour of the current, as to give every reasonable guarantee of their stability. The superstructure, which was executed under the supervision of M. Keller, the

engineer-in-chief, and the Baron Kagenesch, engineer of the Grand Duchy of Baden, does not offer any remarkable features, although it has been well executed and perfectly answers the purpose for which it was intended. To M. Vuigner, chief engineer of the Eastern Railway Company of France, and M. Fleur-Saint-Denis, engineer of bridges and roads, and author of the project, have been awarded a collective medal, for the ingenuity of design for these piers and foundations; and to Messrs. Castor, the contractors, also a medal, for the intelligence of their arrangements and the successful execution of this work, and also for a similar application at the bridge of Argenteuil.

The next bridge worthy of mention is that over the Garonne, at Bordeaux, to connect the Orleans Railway with that of the South on the other side of the river. This extensive work was originally designed by the late M. Alfred Bommart, engineer-in-chief of bridges and roads, and it was after his decease carried into effect under the direction of M. Surell, engineer-in-chief of bridges and roads, by the enterprising contractors, Messrs. Pauwels & Co., under the superintendence of M. De la Roche-Tolay, engineer of bridges and roads, chief engineer of the company, and M. Regnault, engineer of bridges and roads, resident engineer. The total length of this bridge is 500 metres, and it consists of seven openings, the two extreme spans being  $57\frac{1}{2}$  metres each, and the five other spans  $77\frac{1}{2}$  metres from centre to centre of the piers.

The superstructure is formed by wrought iron girders upon the trellis principle, which require no further remark, than that they are well executed. The foundations of the piers were executed by means of cast iron cylinders, which served as air chambers, having the air-lock on a platform attached to the upper part of each cylinder, and which was removed, as occasion required, to replace another length of cylinder. These cylinders were sunk in pairs, side by side, by the compressed air system of M. Triger, and the pressure was given to the cylinders by hydraulic presses. The bed of the river was composed of mud and sand, through which the cylinders were forced, with a depth of water varying from 7 to 13 metres, a current of from 2 to 3 metres per second, and a strong tide rising 6 metres. These were some of the difficulties to be contended with, and which were very successfully overcome by the intelligent foresight of the engineers and the practical experience of the contractors. To MM. A. Bommart, De la Roche-Tolay, and Regnault, the engineers, has been awarded a collective medal for the boldness of the design, and the simplicity and economy of construction of this bridge; and the same recompense has been also awarded to Messrs. Pauwels & Co., the contractors, for their intelligence in carrying into effect the designs of the engineers, and more especially for improvements in the application of hydraulic presses for forcing down the cylinders, on the system invented by Messrs. Fortin-Hermann & Co.

In addition to the above bridges, or viaducts, there are models of several others, of which the superstructure, piers, and abutments, are of masonry. The bridge at Chaumont, by M. Decomble, engineer of

bridges and roads, although displaying nothing original in the design, or construction, is well executed, and is creditable to the engineers and contractors by whom it was designed and constructed.

This important work, which is nearly 700 metres in length, 53 metres in height, was constructed in 14 months; its execution is perfect, and the general effect is very good. To M. Decomble, the engineer entrusted with the execution of the work, has been awarded a medal; and to Messrs. Parent & Shacken, contractors, and Monsieur Gourdin, their engineer, honorable mention for their intelligent co-operation and the excellent arrangement of their executive staff.

The viaduct of Nogent, on the line of railway from Paris to Mulhouse, consisting of three arches, each of 50 metres span, and of 30 arches each of 15 metres span, all in masonry, deserves mention, as a well designed and excellently executed work, for which honorable mention was awarded to M. Pluyette, engineer of bridges and roads, entrusted with the execution of the work.

The bridge of Napoleon, at St. Sauveur, in the Pyrenees, consists of one semicircular arch of 42 metres span in masonry. The foundation presented great difficulty in consequence of the mountain torrents swelling the course of the Cave de Pau. To M. Marx, engineer-in-chief of bridges and roads, and to M. Bruniquel, resident engineer, were awarded collective honorable mention for the good execution of this boldly conceived work.

There must also be mentioned the successful execution of a large bridge over the Vistula, near Dirschau, designed by M. Lentze, for which, and for the ingenuity of the inclined planes on the Oberländische Canal, designed by M. Steenke, medals have been awarded to the Minister of Commerce of Berlin, and to the Royal Engineer Works at Dirschau (Zollverein, 1338). To Messrs. Schnirch & Filzinger (Austria, 626), for the bold and successful bridge over the Danube Canal at Vienna, and to the State Railway Society (Austria, 628), for their good structure, introducing improvements by Rupert in lattice bridges, and for the excellence of execution of these and other important works, medals have been awarded.

To Messrs. Klett & Co., of Nuremberg (Zollverein, 180), a medal has been adjudged for the boldness of the design and the successful execution of the railway bridge across the Rhine, at Mayence, on the system introduced by M. Pauli. This bridge has a very large span, and is of singularly simple construction, offering great facilities for repairs and for keeping in order, by painting, &c., all parts being accessible.

To the Commissioners of New Brunswick was awarded honorable mention for the utility of the bridge works, of which models were shown.

**II. HARBORS AND DOCKS.**—With regard to this department there are several works particularly worthy of notice; and amongst the most important must be mentioned the great “digue,” or breakwater of Cherbourg. The history of this great work is very remarkable, and the structure itself presents a great variety of operations, equally

instructive from their failure and their success. There have been tried here consecutively the ingenious yet abortive idea of the wooden cones filled with small rubble stone—the small rubble upon the *pierre perdu* system, which was equally unsuccessful—then the larger rubble system—and finally the béton and masonry systems, by means of which this great work has been eventually completed. All these plans exhibit considerable ingenuity and skill; nevertheless, it must be admitted that the construction of this great work, at the outset, evinced great deficiency in the knowledge of those first principles which should guide the engineer in the construction of works of this nature and magnitude.

The breakwaters of the Carthaginians at Tyre and Sidon, of the Greeks at Athens, Halicarnassus, Ægina, and in numerous other places, as well as those of the Romans at Ostia, Civita Vecchia, Ancona, Naples, and other ports in the same vicinity, show that the simplest and most economical mode of constructing barriers, or breakwaters, to resist the violence of ocean storms, was by throwing down, or depositing, rough undressed blocks of stone, as raised from the quarries, and allowing them to form their own slope, or inclination, by the action of the waves, until finally the masses, thus thrown down, become settled, when their permanence was further augmented by the growth of seaweed and the drift of the sand into the crevices; so that these works have remained unaltered until the present day. The experience, however, derived from these works does not appear to have been taken advantage of until within a comparatively recent period, and hence the variety of systems introduced in the construction of the breakwater at Cherbourg. In fact, instead of starting from the point of demonstrated success, a comparatively tentative process would appear to have been pursued; whereas, if the knowledge of the past had been taken advantage of, much trouble and cost would have been avoided.

It is to be regretted, in an engineering point of view, that the position of the breakwater should have been determined by purely military considerations, which demanded a direct line between the forts Pelee and Querqueville, thus materially reducing the extent of the roadstead.

The history of this great work, as given in the works of M. de Cessart and MM. Alexis de Tocqueville, Cachin, and Bonnin, &c., as well as in the "*Annales des Ponts et Chaussées*," conveys much information. Due honor should be given to the several able engineers-in-chief and to their subordinates, who have brought the work up to its present satisfactory state. The names of the chief engineers are:—

Captain la Bretonnière, Royal Navy, 1777 to 1782.

M. de Cessart, inspector of bridges and roads, 1782 to 1792.

M. Lamblardie, inspector-general of bridges and roads, 1792 to 1793.

When an interval occurred until 1802, when the works were resumed.

Le Baron Cachin, inspector-general of bridges and roads, 1802 to 1823.

M. Fauques Duparc, divisional inspector of bridges and roads, 1823 to 1838.

M. Reibell, inspector-general of bridges and roads, 1838 to 1853, when the work may be said to have been completed, and to the latter eminent engineer and his able coadjutors, MM. Virla, Mahyer, and Bonnin, engineers of bridges and roads, and to their predecessors and assistants, a collective medal has been awarded, on the completion of this important work, after so many years of persevering efforts, due to the judicious use of all the resources induced by the progress of marine construction.

It is not any detraction from the merit of the many able engineers who have been employed upon this great work, to say that every allowance must be made for the want of knowledge and experience which existed at the time when it was commenced; and as a matter of scientific inquiry, it is most interesting to place on record all the facts of the progress, and to compare the modes employed with those of the present day.

The new port of Marseilles is a great work, which has been planned and executed upon an extensive scale by M. Pascal, engineer-in-chief of bridges and roads. It is situated to the eastward of the old natural harbor, formed by a creek, which was taken advantage of, and around which the town sprung up. The new artificial harbor consists of a series of wet docks, or basins, formed by moles, or breakwaters, constructed in the open sea. They run parallel to the shore, and communicate with each other by openings and locks through the cross walls which separate them from each other. The outer, or boundary sea wall, connecting the whole system, answers the double purpose of a breakwater on the outside, and a quay wall on the inside; and at each end of these docks is an outer, or entrance harbor, so that vessels can use either, according to circumstances, and can pass from one to the other, as convenience may require. There is, also, a connexion with the old harbors. The general design of this harbor is good, but the sea entrances are scarcely sufficiently protected against the swell of the sea during storms. The details of the construction are entitled to considerable credit, for every class of materials has been utilized to the greatest extent; the smallest stones being used in the interior and the largest in the exterior, where the face is exposed to the greatest action of the sea. The outer face, or sea slope, of the great exterior breakwater is protected by large masses of *béton*, formed into artificial blocks, each weighing from 25 to 30 tons, which are said to be immovable by the most violent action of the waves; and so far they have resisted the disintegrating effects of the sea and the atmosphere and with success, although further experience is necessary, before the *béton* masses can be pronounced to be indestructible. Great credit is due to the French engineers, amongst the earliest of whom may be mentioned M. Poirer, for reviving this ancient system of building, and to M. Pascal, the engineer-in-chief, the award of a medal is made for the methodical and scientific direction of these important and extensive works, including the utmost economy, without sacrificing the ex-



cellence of construction, and to Messrs. Dussard, Brothers, of Marseilles, the contractors, honorable mention for their intelligent assistance in the execution of important parts of the works.

The lock-gates of the docks, at the port of St. Nazaire, are specimens of timber constructions of very large dimensions, not requiring the use of any logs of large scantling; and M. Watier, engineer of bridges and roads, the author of the design, and the constructor of the first gates on this system, to whom honorable mention has been awarded, is entitled to great credit for the boldness of the design and the ingenuity of the construction, in which he was strenuously supported and succeeded by M. Leferne, engineer of bridges and roads. The general works of the port being first under the direction of M. Jegou, and subsequently under M. Chatoney, engineers-in-chief of bridges and roads.

The lock of the citadel and the graving dock of the Eure basin at Havre are important works. The graving dock and its entrance locks are designed upon a very large scale, with the view of receiving the vessels of heavy tonnage engaged in the trade with New York; the depth of water on the cill being  $8\frac{1}{2}$  metres at low water of spring tides, and the locks being  $30\frac{1}{2}$  metres in length. The construction of the walls is of the best quality, and much ingenuity has been exhibited during the progress of the works, as well as in the general designs for the extension of the port of Havre, for which there has been awarded a collective medal to M. Bouniceau, engineer-in-chief of bridges and roads, and to MM. Bellot and Lemaitre, resident engineers.

(To be Continued.)

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### *Iron Piers for Railway Bridges in Alluvial Districts.*

From the Lond. Civ. Eng. and Arch. Jour., Oct., 1862.

(Continued from page 170.)

As it is considered that uniformity of parts, as far as practicable, is of as great importance in bridge work as in other mechanical structures, a uniform span of 60 feet is adopted for all the iron bridges on the Bombay and Baroda line, this being considered the most economical in reference to the general heights of the piers. One end of each girder is fixed on the pier, while the other end is left free to move, and carried on a pair of small rollers to allow of expansion and contraction. The weight of the entire 60 feet superstructure for a single line of rails is 24 tons, being 8 cwt. per foot run, and the cost is about £400. In the construction of piers adopted for inland rivers with deep water, say 20 to 50 feet, but not tidal, where the current is always in one direction only, here the oblique piles, acting as struts, are required only on the lower side of the bridge, and the timber fenders only on the upper side. In the case of piers for inland rivers with shallow water of not more than 20 feet depth, the oblique piles can be dispensed with altogether. Where there is a rock foundation, the screws are omitted, and the piles are simply let into the rock about 2 feet and filled round with cement, allowing of great rapidity of erec-

tion in this case. The position of the roadway may be either between the main girders, or upon the top of them. The upper position is preferable for the roadway, because it combines the effect of both the main girders in resisting forces that tend to produce buckling of the compression beams. The upper or lower position of the roadway, however, is decided by the amount of headway under the bridge, or the clearance between the bridge superstructure and the highest known flood level of the river, which should not be less than 5 feet. In every case the power of the compression beams to resist buckling is made ample, and a horizontal diagonal bracing of T iron is provided between the cross girders carrying the roadway, continued from pier to pier; and where the roadway is on the top of the main girders, oblique stays are added, to secure the requisite stability and freedom from vibration in the roadway and girders.

The use of animal power was adopted in screwing down the piles of the great Nerbudda bridge, where a large part of the river bed is uncovered at low water, and it is only in such situations that animal power has been made available direct by means of a long lever. The general practice has been, where the foundations are not always under water, to hoist the piles into the proper position by shear legs, and hold them in this position by guides whilst they are screwed into the ground by a crab winch acting on the end of the lever; but where the ground is always covered with water, a staging has been erected on timber piles surrounding the site of the pier. Latterly the principle of floating rafts has been successfully adopted instead of fixed staging.

Of the piers nearly half were supplied by the Horseley Iron Co., Tipton, and the rest by the Victoria Iron Co., Derby. There is always a difficulty in carrying cast iron safely across the sea, from the great risk of breakage in shipment and in conveyance by land, as well as the chance of disasters at sea; but in the case before us altogether only about 5 per cent. of loss from all causes in the cast iron work occurred, which is a smaller proportion than usual in similar cases. The first part of the superstructure was made by Messrs. Kennard, at Crumlin; but the greater portion by Messrs. Westwood, Bailey and Campbell, London Yard, Isle of Dogs. For the erection of the work in India, the engineers and foremen alone were sent out from England, and all the other workmen employed were natives: Colonel Kennedy states that the natives make good workmen in a very short time, and then get on rapidly. As a consequence of the additional employment, the price of labor has been doubled by the railway works throughout the district traversed by the line.

The practice of cutting down the dimensions too fine in such structures is to be avoided, and a liberal margin ought to be left beyond the calculated strength, to allow for strains which could not be taken account of with the same accuracy as simple transverse and longitudinal strains. Buckling is a frequent source of extra strain, particularly where there is any considerable depth of girder, and is therefore required to be carefully provided against by increasing the size of the

sections and arranging the iron in such a form as would enable it best to resist buckling under compression. In the girders employed, all the bars subject to compression were made of a cross shape in section ; and the greatest strain, either of tension or compression, on any part of the girders amounted to only  $3\frac{3}{4}$  tons per sq. inch under the heaviest practical load. The greatest longitudinal motion observed in 24 hours amounted to  $\frac{3}{16}$  inch in one span of 60 feet. In the dimensions of the girders great allowance was made to provide against buckling and the strains produced by concussions, and there were only a very few places at which the strain ever came up to the maximum of  $3\frac{3}{4}$  tons per square inch, while every where else it was much below this amount, so that the strains never approached the elastic limit of the iron.

The pile lengths were cast vertically, and the joints were generally cast with sufficient accuracy to go together without any fitting ; but where necessary they were chipped to a level face, and care was taken to insure a uniform thickness of metal throughout the flanches. Every piece of iron work was dipped when hot in a bath of linseed oil, and had afterwards two coats of good oil paint. After erection, frequent and thorough painting are relied upon for keeping the iron from rusting. From an examination of several old iron structures, it has been found that the cast iron generally stood well, but the wrought iron shows evidences of corrosion after it has been up about 20 years, and it could never be relied on unless frequently painted or otherwise protected. The prevention of iron from rusting is a question of general importance, and every encouragement should be given to investigation of the subject, with a view to obtaining some really permanent protection. It is clear that even with its present liability to oxidation iron is decidedly the cheapest material for large bridges in general, particularly in alluvial districts : but its durability and renewal are dependent mainly on its thorough protection from oxidation. The object to be sought is not simply to secure the best protection out of a number of modes, of which all may be defective ; but to arrive at an absolute means of preservation, if that be possible.

Tar has proved a very effective material for preserving the bottoms of iron ships from rusting, and is applied also inside vessels. On the Clyde large ships of 2000 or 3000 tons burden are protected inside with a coat of varnish made from purified coal tar, which is found a very efficient protection. A clean surface of the iron for laying on the varnish is all that is required, and it has a fine polish ; the coat lasts 7 or 8 years when protected by a lining of wood work in front. The varnish may be laid on cold, and the smell is all gone in a few days ; the cost is much less than red lead paint. This plan has also been applied to the inside of steam boilers, where the uptake from the furnace passes through the steam room of the boiler, and it prevents oxidation and scaling of the iron from the action of the steam for a long period : it ought, therefore, to be suitable for such structures as the bridges described.

The lower lengths of the piles are filled with concrete, which renders them solid inside, so that each pile stands on a solid foundation of  $4\frac{1}{2}$  feet diameter. Much accuracy was required in getting the piles

correct in level : this was managed by screwing them down a little further if necessary ; and as there are four lugs at each end of the several lengths for attaching the diagonal bracing, the level could be adjusted to one quarter of a revolution of the screw. Where the piles stood on a rock foundation, a piece of the required length was cut off the bottom of the lowest length, leaving the flanch at the top for bolting to the next length ; or else the rock was cut away deeper to get the proper level. A few cases occurred of a pile being broken in screwing down, and it was then very difficult to get the screw out again ; this was one of the chief difficulties that had been met with in erecting the bridges. At the Nerbudda bridge the sudden abandonment of the work, caused by an outbreak of cholera and followed by monsoon floods, left some single piles unsupported, which were broken ; and one or two of these could not be got out again, so that it became necessary to alter the spans in two cases, selecting fresh sites for the piers, in order to get clear of the broken piles. Rapidity of fixing is of special importance in India, for on account of floods and storms the working year for such operations can be reckoned at only about eight months ; and the facility of erection with this construction of piers and superstructure is so great, that by beginning at both ends at the same time, they could now bridge the broadest river in a single season.

### *Solid Matter contained in the Waters of the Hooghly.*

From the Lond. Civ. Eng. and Arch. Journal, Jan., 1862.

In regard to the amount of solid matter contained in the waters of the Hooghly, it was stated, that although Major Rennell had in his "Memoir of Hindostan" estimated the water of the Ganges to consist of one-fourth part mud, yet in other writings he had given it as only the  $\frac{1}{200}$ th part. This agreed more nearly with Mr. Piddington's experiments, which showed the quantity to be the  $\frac{1}{615}$ th part, and with the Rev. Mr. Everest's, who made it the  $\frac{1}{356}$ th part, both during the rainy season. The Nile contained  $\frac{1}{120}$ th of its bulk in mud, and the Humber  $\frac{1}{160}$ th, of which latter, sand formed about 75 per cent. But even allowing that 78,000,000 cubic yards of solid earth were deposited yearly in the Hooghly and its estuary, this would only give  $1\frac{1}{2}$  inch in depth over an area of 600 square miles, included within the 3-fathom contour ; and if the area was extended to the 5-fathom contour, and embraced also the inlet of the Hooghly, then the area would contain 1200 square miles, and the deposit would only amount to  $\frac{1}{4}$ -inch in depth.—*Proc. Inst. Civil Eng.*

### *On the Construction of Iron Roofs.* By J. J. BIRCKEL.

From the London Artizan, September, 1862.

(Continued from page 153.)

So far we have investigated the conditions of stability of those kinds of triangular roofs most generally adopted, and which we can best recommend to our readers. We purpose to treat of circular roofs in a separate paper, and have designedly omitted the consideration of them in the present investigation.

Having learned how to determine the relative amount of stress upon the various parts of a principal, we will now define the total amount of pressure which the roof, under certain circumstances, may have to resist. Among the accidental sources of pressure, those of wind and snow form the most important items, because both may occur simultaneously. According to General Morin's observations, snow may accumulate upon a roof to the depth of 20 inches, and as its weight is  $\frac{1}{10}$ th that of water, the pressure due to this element would be about 11 lbs. per square foot; the same philosopher, however, thinks that one-half this amount will make ample provision; we will keep on the safe side, and suppose it to be 6 lbs. per square foot.

Respecting the wind, we have subjoined a short table of the pressure produced at various speeds upon a plane of resistance supposed to be at right angles with the direction of the wind.

Speed in feet per second.	Pressure per square foot.	Speed in feet per second.	Pressure per square foot.
ft. in.	lbs.	ft. in.	lbs.
10 0	0.2	46 0	4.7
13 9	0.6	65 7	9.6
26 3	1.5	131 0	38.4
35 7	2.8		

General Morin, from whose work the above data are quoted, thinks that a direct pressure of 3 lbs. per square foot is quite sufficient to reckon upon, but English engineers differ from him on that point, and make allowance for a pressure of 7 or 8 lbs. per foot. As there is a great probability that there will be neither heavy rain nor hail while the maximum weight of snow rests on the roof, it may be assumed with safety that the two items of accidental pressure just defined will make sufficient provision for any other sources of accidental stress, of which, therefore, we need not take any special notice. In the following tables we give the items of permanent pressure due to the covering and to the structure of the roof itself, which, added to the items previously defined, will make up the whole weight, which must form the basis of calculation of the strength of the roof.

*Table of Weight of Covering.*

Nature of Covering.	Weight in lbs. per square foot.
	lbs.
Common Tiles . . . . .	13
Hollow Tiles . . . . .	16 to 19
Slates . . . . .	8
Rolled Copper . . . . .	3
Zinc . . . . .	2
Galvanized Sheet Iron . . . . .	2
Corrugated Sheet Iron . . . . .	2½
Asphalte . . . . .	5½

Table of Weights of Principals and Purlins.

Distance of Principals.	Span.	Weight of Principal	Weight of Purlins for one bay.	Weight per square foot of roofing.	OBSERVATIONS.
ft. in.	ft. in.	lbs.	lbs.	lbs.	
6 6	26 0	137	225	2.03	<p>These data are quoted from General Morin's work; principals supposed to be trussed as per diagram No. 2; their weight in this table has been increased by the amount of one-fourth for deficiency in rafters; angle of roof about 25°.</p>
6 6	40 0	337	290	2.20	
6 6	65 9	888	418	2.87	
6 6	82 0	1668	482	3.80	
9 10	26 0	194	508	2.59	
9 10	40 0	502	653	2.76	
9 10	65 9	1387	943	3.39	
9 10	82 0	2625	1088	4.34	
13 1	26 0	245	959	3.33	
13 1	40 0	580	1233	3.26	
13 1	65 9	1705	1781	3.81	<p>Example No. 1 to be described.</p> <p>" 2 "</p> <p>" 3 "</p> <p>" 4 "</p> <p>" 5 "</p>
13 1	82 0	2755	2055	4.22	
Mean weight per square foot 3.22 lbs.					
9 0	84 0	4480	1980	7.10	
14 0	54 0	2240	4935	8.83	
6 6	55 6	2520	1631	10.0	
6 0	26 0	600	330	5.34	
20 0	72 0	3936	6116	4.77	
Mean weight per square foot 7.2 lbs.					

From this it appears that General Morin's theoretical roofs are a little less than half as heavy as those selected from actual practice; but, as we have been very careful in our selection, we are inclined to think that the theoretical roofs are considerably too light.

If, now, we sum up the pressures arising from the various sources enumerated, we shall find that the loads per square foot for different kinds of covering, are as follows:—

Nature of Covering.	Weight in lbs. per square foot.
	lbs.
Common Tiles . . . . .	33
Hollow Tiles . . . . .	29
Slates . . . . .	28
Rolled Copper . . . . .	23
Zinc . . . . .	22
Galvanized Sheet Iron . . .	22
Corrugated Sheet Iron . . .	22½
Asphalte . . . . .	27½

The load of 40 lbs. per square foot, which is generally taken by English engineers as a basis in the calculation of roofs, is by no means exaggerated, though it may be quite sufficient. Having thus provided our readers with all the data required for the determination of the strength of the various parts of a roof, we will now proceed to the examination and description of the examples already referred to, and point out such practical details as may be of especial interest in the study upon which we are engaged.

Example 1 is the roof over the Longton New Market, Staffordshire, and was designed by Mr. Burrell, the architect of that place. In this case the rafters are not allowed to meet at the apex of a triangle, but are connected by means of a collar some distance below that apex; the statical conditions of the trussing, however, are not changed on this account. The stresses upon the various parts of the principal are to be determined as if the rafters met at the apex, and the stress upon the collar is equal, and of contrary nature to that on the main tie, as due to the primary truss. To satisfy the minds of our readers we have appended to the drawing of the roof the diagram of stresses. The rafters here are made of two angle irons, 3 in.  $\times$  1½ in.  $\times$  ¼ in., bolted back to back, having an aggregate area of 2¼ square inches, with a wooden packing between them of adequate strength almost by itself to do the work of the rafter, if it were continuous; as it is, however, it forms no element of strength, and is only here for convenience of fixing the boarding which carries the slate. The thrust upon the rafter is 7¾ tons, and the stress upon the square inch, taken into account the bending moment, is about 8 tons. The tie rod is made of flat bars, and double, for convenience of making the joints; it has an area of 1·8 square inches, deduction being made for bolt-holes, and, the maximum pull being 7 tons, sustains a stress of about 4 tons per square inch; in these respects, therefore, the roof is well proportioned. The secondary trussing, however, is defective, and as the bar instead of being a strong strut, is only a thin flat rod, the upper secondary truss can scarcely act as such, and, in consequence, a great stress is thrown upon the upper portion of the rafters. The collar supports a lantern roof, the vertical sides of which are glazed, the whole of the framing and sash-bars being made of wood. As the principals are only 6 ft. 6 in. apart, there are no purlins to the roof, but a continuous layer of 1½ in. boarding spans from principal to principal, and carries the slates. The proportion of wood in this roof is such as to lead us to suppose that it could never have been intended to be fire-proof, and on that ground we are inclined to ask the architect why he has introduced so much iron into it, and thrown so much more expense upon the purse of the market commissioners? or else to ask this latter respectable body why they did not grant the architect funds sufficient to enable him to realize the above named most desirable object.

Example 6 is a roof and shed for the Russian Admiralty, and was, in the first instance, designed with an intended space of 10 feet between the principals. At the express desire of the Russian officials, however, this distance has been increased to 20 feet, although by so doing the weight of the whole structure has been somewhat increased also. The whole width of the space roofed over is 72 feet, but the actual span of the principal is only 52 feet, there being a space of 10 feet on each side, covered with a lean-to roof, glazed in the whole of its length, and so placed as to be continuous with the main rafter. This arrangement has been adopted in imitation of the sheds at Chatham Dockyard, for convenience of carrying a line of shafting on the

main standard. The roof is very high pitched, being at an angle of  $45^\circ$ , on account of the heavy falls of snow experienced in the Russian climate; a louvre roof at a smaller angle of  $30^\circ$  spans about  $\frac{1}{4}$ th the whole roof, the vertical sides of which are glazed to admit the light into the centre of the building, and in order to prevent any great accumulation of snow upon it, a small platform has been provided upon the ridge to admit of a man walking along and pushing the snow down when that is required. The whole of the shed, with the exception of the glazed portions, is covered and closed with corrugated galvanized iron, No. 20 W. G. This circumstance has enabled the constructors of the roof, without incurring any additional expense, to place the purlins immediately over the centres of resistance of the trussing, and thus the rafters are relieved from all bending stress. The thrust upon them is  $25\frac{1}{2}$  tons, to resist which we have an area of  $4\frac{1}{2}$  square inches, causing a stress of  $5\frac{3}{4}$  tons on the square inch. The main tie rods and braces are made of flat bar iron, for the sake of cheapness and expedition in the execution of the work; the lower ties are made of two bars,  $3\frac{1}{2}$  in.  $\times$   $\frac{7}{16}$  in., and deduction being made in the area for bolt-holes, sustain a stress of  $8\frac{1}{2}$  tons to the square inch; the braces are made of a single bar  $3\frac{3}{4}$  in.  $\times$   $\frac{1}{2}$  in., and sustain the same amount of stress; the raised portion of the main tie sustains only a stress of  $4\frac{1}{2}$  tons on the square inch, and might have been made a little lighter, but for the sake of appearance. The glass here, as in some of the previous examples, is carried by T iron sash bars, placed at distances of 12 inches, with the exception of the glazed portions of the louvre roof and of the gable end, where the sashes are made of wood. The purlins are of T iron, excepting in those places where they carry the sashes, being there made of channel iron; owing to the great span between the principals, they are trussed, but might with safety have been a little lighter.

(To be Continued.)

### *The Middle Level Inundation.*

From the Lond. Civ. Eng. and Arch. Jour., Jan., 1863.

The calamitous inundation of the Middle Level district a few months since, and the various means adopted to remedy the disaster, were described in this *Journal* at the time of the occurrence. The subject is, however, so important and full of interest, that the following narrative of the event, and of the means employed to repair the Middle Level Sluice, will be acceptable to our readers. It was delivered in the course of the introductory address at the commencement of the present session of the Institution of Engineers in Scotland, by Mr. William Johnstone, the president:—

The early Dutch engineers, brought over by James I. of England, divided those immense tracts into levels or confederations, each getting peculiar privileges granted them by parliament, with power to



levy rates on the acreage benefited by their main drains and outfalls, for their construction and maintenance.

The Middle Level is one of those, consisting of 140,000 acres, extending nearly to Peterborough, and cut from off the seaboard by a belt of intermediate fens 8 miles wide, under separate commissions, each maintaining, by their own taxation, independent drains and outfalls. The only thing common to all is the river Ouse, into which they all in that quarter drain, each commission subscribing to a general purse for the maintenance of its banks. This river rises in Bedfordshire, pursues a north-easterly and very tortuous course, receiving contributions from the Cam and other rivers as it passes through Cambridgeshire, and reaches the sea through the Norfolk estuary, a few miles below Lynn. It is tidal for many miles into the interior, which during floods hinders the free passage of the water to the sea, and often prevents the gates of the inland main drains being opened for several days together.

The original outfall of the Middle Level waters into this river was, on account of the intermediate fens already mentioned, placed some 15 miles from the sea, and was particularly subject to irregularity of action. The commissioners consulted the late Mr. James Walker, an engineer who was eminent for his skill in hydraulic works. Mr. Walker advised the entire removal of the outfall sluice 9 miles further down the river, and that parliamentary powers should be sought to make a main drain across the intermediate fens to it. This was accordingly done, and, after encountering a severe parliamentary contest, the act was obtained.

The sluice consisted of three 20 ft. openings, the sills being 6 ft. below low-water of spring-tide; strong pointed gates opening outwards prevented the ingress of the tide so soon as the level of the water in the river exceeded that in the drain. The drain, which is perfectly straight, is on an average 130 ft. wide; and its bottom, for the 8 miles across this district, is 7 ft. below low water. The level of the adjoining lands being only 3 ft. 6 ins. above low-water for a length of 6 out of the 8 miles, really gave good grounds for objecting to such a dangerous element being carried out on such a large scale through their very midst. But what they most dreaded was an accumulation of upland or fresh water in the drain during floods, more than could be discharged in the interval of low-water, the pressure of which on banks which, however carefully constructed originally, might by negligence in maintenance become unfit to meet all exigencies. On that ground they opposed the bill, and obtained protective clauses; but it does not seem to have occurred to them that any failure could ever take place in the outfall sluice, and it will be for the courts of law to decide whether those clauses do not altogether exclude the sufferers from any compensation whatever for the damage done by the sea. This is mentioned for two reasons—first, to point out that the land inundated was not the Middle Level at all, but the intermediate districts; and secondly, to be excused from giving, directly or otherwise, any opinion as to the sufficiency or insufficiency of the works which for eighteen

years stood well, and almost convinced the most timid opponents that their former fears were groundless. Everybody admitted the drain and outfall sluices, from their magnitude and apparent efficiency, taken as a whole, to be a masterly piece of engineering.

To the Middle Level the boon was incalculable, and far more than realized the most sanguine expectations of its immense population. Pumping engines in many districts were abandoned, and land which was worthless during the old state of drainage soon brought upwards of £50 an acre.

On the 4th May, this year, Mr. Walker's grand sluice, without much previous symptom of decay, fell in pieces, as if rent by an earthquake; and the tidal waters of the Ouse rushed with indescribable fury up to the drain, until at the end of the eight miles they were checked by the barrier sluice on the frontier of the Middle Level district. The drain for this distance became a sort of creek; and had its banks been strong enough to have resisted until a dam could have been made across the mouth, no inundation to the adjoining country would have taken place. This state of things lasted for a week, several minor breaches in the banks being successfully stopped at every tide, until at last the west bank gave way at a point situate 4 miles up, and a tide 14 feet higher than the land rushed over the devoted country, then beaming with most luxuriant crops. The land, being all of the same level, was not for a few tides covered to any depth, consequently the farmers were able to escape with their lives, and also to secure their cattle. All attempts to stop the breach were perfectly futile, owing to the rush of water back to the drain again during low water. This altered state of things had also a wonderful effect on the dam the farmers were trying to put across the mouth. The twenty-four barges, varying in size from 30 to 80 tons each, which had been loaded and sunk in the yawning chasm to form a base for some thousands sacks of clay to be built on at low water, were speedily separated and turned over; and nothing that could be sunk or thrown into the torrent would for a moment remain.

By the late Mr. Walker's recommendation, Mr. Hawkshaw visited the scene of disaster to see what could be done; and he at once gave orders to give up all attempts to stop the breach in the bank of the drain, which by this time was about 100 yards wide, because, if successful, the chances were that the opposite bank would give way, and do still greater damage to the lands on the other side. He also abandoned the idea of constructing the dam at the mouth, most of which had now been carried to sea, as, in addition to the sacks of clay and other make-shift material which were being thrown in, he wished to drive a few piles; so, taking advantage of a timber bridge of three openings across the drain near the mouth, he had all the pile engines that could be found in the neighborhood placed on it, and set to work; nothing was to be put in until the piles were driven on either side of the bridge, and strongly braced together; the planking was then to be taken up, and the prepared material dashed in. Matters were so arranged that much progress was made in the course of two days with

the driving of the piles ; but during the progress of this work, up turns one of the huge 80-ton barges (which was supposed to have followed its companions out to sea), and, dashing against the row of newly driven piles, snapped them right through, and carried away the entire bridge as well as the piling engines and necessary appliances—the men only escaping with their lives. Two other occupation bridges shared a similar fate, but a bridge carrying a turnpike road resisted sufficiently to afford time to secure it. This was a most unfortunate accident, as great difficulty was experienced in getting a supply of pile engines in the neighborhood.

Now was the time for the Dutch engineer, who with Mr. Hawkshaw's consent, had been sent down to try what could be done by sinking cradles, for such was the excitement generally throughout the country, and the imminent peril of the surrounding district, that Mr. Hawkshaw, seeing the time which must necessarily elapse before the destroyed plant could be replaced, and a dam such as he deemed necessary could be constructed, felt he would not be justified in offering any opposition ; but, on the contrary, he heartily supported him. In the meantime, a few tidal and other observations established some facts that set all minds at ease, and went a great way in discountenancing the Dutch mode of procedure. 1st, The land inundated extended 6 miles along the west side of the drain, and was 2 miles broad at the widest place. On an average the water was 5 feet deep over all, being luckily confined to that area and depth by the existence of two roads, which stood about 1 ft. 6 in. above that level, and surrounded it for many miles. And 2d, The tidal observations showed that the tide affected the level of the vast lake to an extent of only 6 inches ; so long, therefore, as the level of the roads held good, no further damage could arise by the free admission of the tide. The Dutchman, failing in the first attempt, was preparing a second cradle, when it became a very serious question whether he would not, by pounding up a certain quantity of water every successive layer of cradles he sunk (for to stop it in a few tides was not to be hoped for) gradually, but undoubtedly, raise the level of the water from 9 ft., at which it stood, until, in the course of time, it would approach the height of 18 feet, which was the mark the same tide made at the dam. Where, then, would be the 1 ft. 6 ins. we had to come and go on ? His operation was, therefore, after due deliberation, stopped.

The difference of level of the water in the fen from that in the Ouse arose from the tidal current having to pass 4 miles through the drain before entering the inundated land ; and from the extent of area inundated being no less than 12 square miles, it only affected the height of the water in the fen to the extent of 6 inches, as afterwards explained.

Before giving a description of Mr. Hawkshaw's dam, I may state some of the difficulties he had to contend with—1st, The high water in the inundated fen, as compared to the same water in the Ouse, was as 9 feet to 18 feet, and the tide rose and fell in the fen 6 inches. Nothing approaching low water in the river could ever, therefore, be

obtained in the drain. The only interval of repose, or what might be called slack water, was when the tide outside attained the height of 8 ft. 6 ins., or level of the low, water in the fen. Ten minutes time was sufficient to send a gentle current inwards, which increased in velocity every minute afterwards, until high-water; but the high-water in the river, being 9 feet higher than in the fen, no still water was again obtained until the tide had receded in the river to that level; it then rushed out like a mill stream until the tide rose to 8 ft. 6 ins. again. 2d, The bed of the drain being 7 feet below low-water mark, it followed that, at the time of slack-water, when any work could be done at all, the depth of water in the drain was 15 ft. 6 ins.; this was increased some 2 feet more, notwithstanding all efforts to maintain the bottom. The drain a short distance inside the site of the dam was ultimately deepened to 17 feet for a distance of 20 chains. Great caution was therefore necessary in any attempt to contract the sectional area.

The first thing to be done was to construct across the drain a strong stage 30 feet wide, resting on screw timber piling, which was projected into the current—the capstans on the piles being turned by ropes from the shore. Close piling on each side of this staging was then commenced, and continued from each shore until a clear space of 90 feet in the centre remained, it being considered imprudent to carry it further. This space was divided into twelve openings, by driving twin piles on each side of the stage opposite to each other, at 7 ft. 6 ins. intervals. Great care was necessary in pitching those piles, and it could only be done during the short time of slack-water. Each pile was 14 inches square, and separated from its fellow by the first one having a thin piece fixed to its outer face, against which the second was driven, thus forming two grooves,  $8\frac{1}{2}$  inches wide, for the panels, which were intended to be dropped into the openings, to slide in. Strong waling pieces of whole timber inside and out of each row at top, and as low as the water would admit of at the bottom, kept the whole in gauge, and the transverse timbers and iron bracings communicated any outward pressure through the dam from one row to the other, the outside of the dam being stayed to the side of the drain by double timbers, 60 feet long, the ends abutting against piles backed by a mass of concrete. These struts were placed against the waling pieces at top and bottom, and stiffened by cross diagonals like a girder. The staging was left open at the top, to admit of material being tipped from the two lines of way, laid across the dam; and communicating with the prepared heaps of puddle and other material at convenient places up and down the drain on both sides. Two outside stages, one on either side of the dam, and supported by cantilevers from the twin piles, admitted of almost any quantity of tipping from barrows to make good any scour which the soundings taken at every slack might indicate. The rush of water through the dam thus far completed was, both on the flood and ebb tide, truly alarming; the simple introduction of those piles and bottom walings causing a difference of head level of nearly 5 feet. In the midst of this roaring cataract,

this framework and the dam stood without the slightest vibration being felt.

The greatest and most anxious care was now necessary to preserve the bottom of the drain from the scouring action of such a weight of water passing over it at the rate of 10 feet a second. Tons of broken stone were tipped from the outer stages and thrown overboard from barges, to form aprons on either side. But, except as a last resource, no stone was to be thrown into the centre of the dam, lest it should prevent it afterwards from being made perfectly water-tight. The long panels composed of timber 8 inches thick, not framed, but merely built one above the other, and held together by three long bolts and heavy iron straps, made them quite rigid, and no difficulty was experienced in driving them. They were made with a sharp edge, and dollied down until their top was level with the bottom of the drain or nearly so, and backed well outside with stone. Great quantities of puddle were tipped into the dam at every slack-water; not with any hope of its remaining, but simply to feed the cancer—if I may so express it—and thereby allow less time for the dreadful current to act on the bottom. This was all the more necessary, for the piles on an average could only be driven 14 feet into the ground. All attempts to exceed that depth resulted in fracture. No doubt a bed of gravel existed at that depth totally different in character from the coarse silt and alluvial deposit resting on it, and now so anxiously maintained.

The first attempt at closing the dam resulted in failure from the fracture of two of the twin or gauge piles, which doubtless were injured in the vain attempt to get them deeper into the bottom. No blowing however, occurred, and the panels when liberated were carried off. The greatest apprehension existed until the return of slack-water, when the divers reported no damage, the lower panel driven into the ground, preventing any cutting of the bottom. In consequence of the failure all the other panels down to low-water were drawn, to allow free access to the tide, until the piles could be replaced. This was accordingly done, and a week elapsed in making good the damage and otherwise preparing to meet other contingencies, of which experience was daily pointing out the possibility. All was now ready; the panels were again swung in the gallows frames, ready to be dropped at slack water on the ebb. They were all lowered into their places in twenty minutes, material was then tipped in with great rapidity by the wagons, and the outsides weighted from the barrow stages. All was most successful; a little blowing took place where the stumps of the fractured piles interfered with the proper fitting of the panels in those places. However, by throwing a large quantity of hay, and piling a great quantity of clay bags on each side, it was checked until sufficient puddle was tipped into the centre. This was accomplished in twenty-four hours, and set so completely that not a drop escaped through. The tides no more went up the drain, but ebbed and flowed outside with a stillness which, when compared with the previous day, partook of that oppressive character experienced near a mill, or in the midst of going machinery, suddenly stopped. Syphons 3 ft. 6 ins. in diame-

ter were then placed over the dam to relieve the Middle Level from the surplus water that would not find its way to the Ouse through the old outfall, which for the present was again resorted to. Many thought they would not act. No good reason, however, could be urged against them, and all admitted that it was proper to make the experiment. These syphons have been finished and recently opened, and all found to do their work very well indeed. Their bottom level where they pass over the dam is 18 feet above low-water, and the bottom of the mouths 6 feet under low-water. In spring tides high-water rises 20 feet. These operations have succeeded in relieving the Middle Level of water, and it will be a great boon to the whole of that district.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

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### *Webster's Process for Making Oxygen Gas.*

From the London Chemical News, No. 156.

The following report has been made by Dugald Campbell, Esq., F. C. S., to Messrs. John H. Porter and Co., the proprietors of the patent:—

As requested by you, I have made experiments in order to examine into, and report upon, the process of Mr. James Webster, of Birmingham, for “manufacturing oxygen gas, and obtaining certain other products,” described in the specification of his patent, dated October 19, 1861.

The materials which I employed in my experiments were commercial nitrate of soda of the ordinary quality, and a common oxide of zinc; the first of value, I should say, at from £13 to £14 per ton, and the latter at from 30s. to 40s. per ton.

The mode of operating was as follows:—10 lbs. of the nitrate of soda and 20 lbs. of the oxide of zinc, both previously dried, were mixed roughly together, and thrown into a red-hot retort. In a minute or two, when the oxygen gas began to come off, which was ascertained by the gas having the power of supporting combustion, the gas was made to pass into what was named the purifier, which I shall afterwards describe, and from thence into a graduated gasometer.

When the gas had ceased to come off, the gasometer was shut off from the rest of the apparatus, and the contents of the retort emptied into a tray, and mixed roughly with an additional 10 lbs. of dry nitrate of soda, were returned into the retort, and distilled as before, and when no more gas was evolved, the gasometer was again shut off, and the contents of the retort discharged into a tray, and again mixed in a similar manner with 10 lbs. of the dry nitrate, and distilled as before.

The material in the retort has now become, to some degree, pasty, and is considered no longer fit to have more nitrate of soda added to it, and, from the original weight of 50 lbs., it is now reduced to 37 lbs., or has lost 13 lbs. It consists as follows:

	In 100 parts.					
Sand with oxide of iron	-	-	-	-	-	13.66
Oxide of zinc	-	-	-	-	-	30.20
Anhydrous soda	-	-	-	-	-	24.80
Nitrate of soda with a little nitrate	-	-	-	-	-	31.34

It will be seen from the above that this material contains 24.8 per cent. of anhydrous soda, which is equal to 32 per cent. of hydrate of soda, and, by boiling it in water, this hydrate of soda, together with the nitrate of soda, are dissolved out from the oxide of zinc, and may be readily separated from each other by crystallizing out the nitrate, leaving the hydrate.

But it sometimes happens that from too great a heat being employed in obtaining the gas, or from the nature of the iron of the retort used, that, besides these salts of soda, a salt of iron and soda is formed, namely, the ferrate of soda. This salt is green, and is not separated by crystallization from the hydrate, and consequently would much contaminate it, and render it much less valuable. In my opinion, it is quite easy to avoid such an action taking place.

But in the event of such an action having taken place, the use to which the residual material may be afterwards put to in the process, namely, in the purifying of the gas as it passes through the purifier, alters it, and converts it into a substance more readily to be dealt with.

The purifier, spoken of before, consists of a deep jar, at the bottom of which  $5\frac{1}{2}$  lbs. of water are placed; the gas from the retort is made to enter just above the water, and passes up through perforated trays, on which are spread the 37 lbs. of residual material from the retort, broken into a rough powder, and moistened with 6 lbs. of water, making together 43 lbs.

In all my experiments the residual material remained in the purifier during the distillation of the 50 lbs. of the material only, when it was removed and weighed.

The water at the bottom of the receiver is now strongly acid, with a mixture of nitrous and nitric acids, and has increased in weight in my experiments from 2 lbs. to  $3\frac{1}{2}$  lbs., depending upon the degree of heat used in the process. That being the case, its specific gravity is variable, and in the course of one distillation of 50 lbs., the acid water is not of much value; but it might remain in the purifier during several charges, when it would become strong and of real value, or it might be drawn off, and added to the dry residual material removed from the trays after it has done purifying the gas.

This residual material upon the perforated trays in the purifier, after the passing of the gas from 50 lbs. weight of the materials, has increased in weight in my experiments from 2 lbs. to 3 lbs., according to the temperature at which the materials are distilled, and also according to the nature of the residual material employed in the purifier, and it is now much changed, and the hydrate of soda is now almost

totally converted into nitrate of soda, and any ferrate of soda is decomposed. Its composition is as follows:—

In 100 parts.							
Water and sand	-	-	-	-	-	-	26·27
Carbonate of soda	-	-	-	-	-	-	5 00
Oxide of iron	-	-	-	-	-	-	6·00
Oxide of zinc	-	-	-	-	-	-	22·82
Nitrate of soda with a very little nitrite	-	-	-	-	-	-	39·91

The way which I would suggest of dealing with the above substance, is to add the acid water from the bottom of the purifier to it, so as to neutralize any carbonate of soda which it may contain, and boil it with water, which will dissolve the nitrate of soda from the insoluble oxide of zinc, and the solution of nitrate is afterwards evaporated for the nitrate.

The yield of gas from 20 lbs. of oxide of zinc and 30 lbs. of nitrate of soda, in my experiments, was very close, varying only from 157·85 to 159·03 cubic feet, and the time occupied in each working of 50 lbs. was, as near as may be,  $9\frac{1}{2}$  hours.

I was unable to fix exactly what the consumption of fuel was for one charge, but, from the data I obtained, I should say it was under 9d.

On analyzing the gas I was surprised to find that it contained a considerable per centage of nitrogen, in my experiments varying from 26·50 to 32·80 per cent.; for, independently of its supporting combustion very well, and increasing the illuminating power of coal gas to a great degree, I should not have expected nitrogen to be eliminated from the materials used, by the heat which was employed. However, finding the nitrogen there, it appears to me that it must have got there by using too high temperatures,\* and I think, by experimenting at different temperatures, you may find out one where little, if any, will be produced, or one, at any rate, at which much less will be produced.

\* Acting upon these suggestions, the proprietors have obtained a higher degree of purity in the gas which they find to be improved also by the addition of more water to the materials in the purifier.

### *Proceedings of the Manchester Association for the Prevention of Steam Boiler Explosions.*

From the Journal of the Society of Arts, No. 512.

At the last ordinary monthly meeting of the executive committee, held September 2d, 1862, Mr. L. E. Fletcher, chief engineer, presented his monthly report, of which the following is an abstract:—

During the past month the ordinary visits of inspection have been made, and 8 boilers tested by hydraulic pressure, the following defects being discovered in the boilers examined:—Fracture, 3 (2 dangerous); corrosion, 26 (6 dangerous); safety-valves out of order, 14; water gauges ditto, 10; pressure gauges ditto, 13; feed apparatus, ditto, 4; blow-off cocks ditto, 37 (1 dangerous); fusible plugs ditto, 6; furnaces out of shape, 3; blistered plates, 2. Total, 118 (9 dangerous). Boilers



without glass water gauges, 4; without pressure gauges, 16; without blow-off cocks, 11; without back pressure valves, 31.

The principal cases of dangerous injury which have arisen this month have been due to corrosion, the continued recurrence of which shows the importance of having all boilers examined, not "externally" only, but also "internally and thoroughly."

Another explosion has occurred during the last month to the class of plain cylindrical egg-ended boilers, fired externally. The boiler in question, which was under the inspection of this Association, was one of a series of six connected together, in the midst of which it had worked, being the fourth from one end, and the third from the other. Its length was 30 feet, its diameter 5 feet, the thickness of its plates  $\frac{3}{8}$ ths of an inch, and its working pressure 50 lbs. The rent, as is usual in these cases, occurred at one of the transverse seams over the fire, but the development of the line fracture was somewhat peculiar. In ordinary cases these boilers, on explosion, separate at one of the ring seams into two distinct halves, which fly in opposite directions; but, in the present instance, the first belt of plates was completely severed from the remainder of the boiler and flattened out, having rent through the line of rivets at each of its four edges, while the egg-end had become entirely disengaged from it, and, in addition, was torn into two parts. The remainder of the boiler, which was by far the greater portion, being about twenty-four feet long, had flown to a distance of about eighty to ninety yards, and the chimney, which was reduced to a heap of ruins, had either been swept down by it in its course, or blown down by the impact of the steam.

There was no evidence of there having been either deficiency of water or excess of pressure; while each boiler in the series was fitted with two lever safety-valves of three inches diameter, a glass water gauge, and a back-pressure feed valve. The exploded boiler was about four years old, and had been repaired seven months since, at the part immediately over the furnace, by the introduction of two new plates.

It will be observed that the above explosion is another instance of the liability of these externally-fired boilers to rend at the transverse seams over the fire. The combined duty thrown upon these seams is so great, that there is more uncertainty with these boilers than with those of the more internally-fired double-furnace class in ordinary use in Lancashire. All the points in the latter can be so entirely mastered that they may be thoroughly relied on, and if well made, and in sound condition, can, with proper care in working, be guaranteed as safe for a period of twelve months from the time of examination. Not so, however, with the externally-fired boiler, in which the shell has to endure the entire disruptive strain combined with the direct impingement of the flame. In the internally-fired boiler these two duties are divided; the shell, which bears the tensile strain, being guarded from the intense action of the fire, which the furnace tubes are adapted to bear, from their small diameter and facility for strengthening, either by flanged seams, hoops, or otherwise; while the deposit, which to a great extent rolls off the furnace crowns, and falls

harmlessly to the boiler in one case, deposits itself immediately over the fire in the other. Thus the seam of rivets in externally-fired boilers have to contend with the combined influence of tensile strain, the direct action of the fire, and too frequently with an accumulation of incrustation tending to overheating, and even where this does not form a positive coat, it may yet suffice so to thicken the water that the steam lifts it from the surface of the plate, when over-heating unavoidably ensues; added to which, sudden drafts of cold air, on opening the furnace doors, cool the outer laps of the plate at the seams, which thus become subjected to the constant alternations of expansion and contraction.

Under these circumstances it is not surprising that the seams of rivets in under-fired boilers should frequently be found suddenly to give way, for which the surest remedy will prove to be the substitution of internally-fired boilers in their place. Where, however, those externally-fired are still adopted, it is earnestly recommended, in the first place, that good materials and workmanship should be secured; in the second, that every means should be adopted for the prevention of incrustation; and, in the third, that the seams of rivets should be constantly and narrowly watched, so as to detect the first signs of weakness, which should be immediately repaired.

Ready examination is facilitated by setting these boilers, as some of our members are doing, with a single direct flash flue, in which are a series of bridges, one behind the other, for keeping the flame in contact with the boiler; an entrance being made beneath the furnace bars, as well as a small archway through the back bridges, to allow of a communication throughout.

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For the Journal of the Franklin Institute.

*Rules for selecting the Exponents in Nystrom's Parabolic Construction of Ships, and approximating the Dimensions of a Vessel when its purpose is given.* By JOHN W. NYSTROM, C. E.

(Continued from page 107.)

From the preceding formulas, 7 and 9, we have

$$D = \left( \frac{n' 2n''}{(n' + 1)(2n'' + 3n'' + 1)} \right) L B d,$$

in which the factor in the parenthesis is the co-efficient for the length, breadth, and draft of water of the vessel. Let us call this co-efficient =  $n$ , we have  $D = N L B d$ . In the accompanying Table IV.,  $N$  is calculated for different exponents  $n'$  and  $n''$ , as indicated in the columns. The draft of water in the column  $d$ , means the draft in proportion to the size of the vessel; when the draft is half the beam, it is considered great, and if only  $\frac{1}{8}$ th or  $\frac{1}{10}$ th of  $B$ , it is small. The purpose of the vessel is noted under the Table. Suppose it is required to build a steamer of light draft for the purpose of carrying freight and passengers, we find in the Table that the exponent for the displacement should be about  $n'' = 4$ , and that for the cross-section  $\alpha$  about  $n' = 8$ , when the co-efficient  $N = 0.632$ , and the displacement  $D = 0.632 L B d$ .

Let us assume certain proportions of the length  $L$ , beam  $B$ , and draft  $d$ ; the displacement given in tons  $T$ , we have

$$T = \frac{NLBd}{35}, \text{ or } T = L \left( \frac{NBd}{35} \right)$$

in which the factor in the parenthesis is a co-efficient for  $L$ , and may

be a function  $L$ , so that  $T = \frac{L^3}{0^3}$  and  $L = 0 \sqrt[3]{T}$ . The factor 0 is calcu-

lated in the Table V. for different proportions of  $L$ ,  $B$ , and  $d$ , as required for the different purposes and conditions. Suppose the size of a vessel is given in  $T = 1200$  tons of displacement, to be constructed for freight with moderate speed, and for navigating very shallow water. Required the exponents  $n'$ ,  $n''$ , and the dimensions, length  $L$ , beam  $B$ , and draft of water  $d$ ? From Table IV. we may select  $n' = 10$  and  $n'' = 6$  when  $N = 0.720$ ; find the nearest number to this in column  $N$ , Table V., which is  $N = 0.743$ ; continuing this line to the three columns, of river steamers of light draft, we may select the co-efficient  $0 = 36.8$ , when the length of the vessel will be  $L = 36.8 \sqrt[3]{1200} = 391.1$  feet. Divide this length by the number of the column 82, or

$391.1 : 82 = 4.77$  feet, the draft of water, and the beam

$$B = \frac{35 T}{NLd} = \frac{35 \times 1200}{0.743 \times 391.1 \times 4.77} = 30.3 \text{ feet.}$$

TABLE IV.—To Approximate Size and Shape of Vessels.

<i>d</i>	<i>N</i> <i>n'</i>	Exponents for Displacement <i>n''</i> .								
		2	2.5	3	3.5	4	5	6	8	10
Draft of Water. Light. Midding. Deep.	2	.356	.397	.429	.453	.494	.500	.528	.558	.577
	2.5	.381	.425	.459	.486	.508	.541	.566	.597	.620
	3	.400	.447	.482	.510	.533	.563	.594	.627	.650
	3.5	.414	.462	.500	.528	.552	.589	.615	.650	.673
	4	.427	.476	.514	.544	.569	.606	.633	.668	.693
	5	.444	.496	.535	.567	.592	.631	.660	.696	.722
	6	.458	.509	.550	.583	.610	.649	.679	.717	.742
	8	.474	.529	.571	.605	.632	.673	.704	.743	.770
	10	.490	.547	.590	.625	.654	.696	.720	.759	.797
Purpose.		Speed and Passengers.			Freight and Passen- gers.			Freight and Slow Speed.		

TABLE V.—Length of Vessels = Tabular number  $0 \sqrt[3]{T}$ .

$n' \& n''$ N		Proportion of Draft and Length of Vessels.								
		8	12	18	26	36	48	64	82	102
Heavy Ordinary Sailing Freight. Vessels. Yachts.	.356	14.9	19.0	23.7	28.9	34.0	38.9	43.6	47.2	48.0
	.425	13.9	17.7	22.1	26.9	31.7	36.2	40.6	43.9	44.5
	.482	13.3	17.0	21.2	25.8	30.3	34.7	38.9	42.1	42.7
	.528	12.9	16.5	20.5	25.0	29.4	33.7	37.7	40.8	41.3
	.569	12.5	16.0	20.0	24.4	28.7	30.8	36.8	39.8	40.3
	.631	12.1	15.5	19.4	23.5	27.6	31.6	35.4	38.3	38.8
	.679	11.8	15.1	18.8	22.9	26.9	30.8	34.6	37.4	38.0
	.743	11.6	14.8	18.5	22.5	26.5	30.3	34.0	36.8	37.2
	.797	11.2	14.3	17.9	21.8	25.6	29.3	32.9	35.6	36.0
Conditions.	Vessels for Deep Water.			Ordinary Navigation.			River Steamers, Light Draft.			

Should a greater beam be required, select  $\phi$  in the column 102 when the draft of water will be less.

For light draft and speed, the exponents should be selected towards the corner .490, Table IV.; and for freight and light draft towards the corner .797. For heavy freight and light draft, the proportions of the vessel should be selected towards the corner 36.0, Table V.; sailing yachts for deep water towards the corner 14.9, and ordinary vessels for deep water in the middle of column 12.

The following Tables VI. and VII. are calculated for twenty parabolic exponents.

TABLE VI.

Exponent $n$ or $n'$ .	Sub-ordinates for the Water-line $a$ or Cross-section $\mathcal{M}$ . $b = 1$ .							$a = BL \times$ $\mathcal{M} = b d$	$k$ .
	1	2	3	4	5	6	7		
2.	.2345	.4375	.6094	.7500	.8593	.9375	.9844	.6666	1.94
2.25	.2595	.4766	.6527	.7897	.8899	.9558	.9834	.6923	1.98
2.5	.2838	.5129	.6912	.8232	.9139	.9687	.9944	.7142	2.00
2.75	.3073	.5466	.7254	.8513	.9326	.9779	.9967	.7333	1.98
3.	.3301	.5781	.7558	.8750	.9472	.9844	.9980	.7500	1.94
3.25	.3521	.6074	.7829	.8944	.9587	.9889	.9988	.7647	1.91
3.5	.3733	.6346	.8070	.9116	.9677	.9922	.9993	.7777	1.88
3.75	.3939	.6600	.8284	.9256	.9747	.9944	.9995	.7894	1.85
4.	.4138	.6836	.8474	.9375	.9802	.9961	.9997	.8000	1.82
4.5	.4517	.7260	.8794	.9557	.9878	.9978	.9998	.8181	1.76
5.	.4871	.7627	.9046	.9687	.9926	.9990	.9999	.8333	1.70
5.5	.5202	.7945	.9246	.9779	.9954	.9994	.9999	.8461	1.64
6.	.5512	.8220	.9404	.9843	.9972	.9997	1.000	.8571	1.58
6.5	.5802	.8459	.9528	.9889	.9983	.9998	1.000	.8666	1.52
7.	.6073	.8665	.9627	.9922	.9989	.9998	1.000	.8750	1.46
8.	.6564	.8989	.9767	.9960	.9996	.9999	1.000	.8888	1.34
9.	.6993	.9249	.9854	.9985	.9998	.9999	1.000	.9000	1.28
10.	.7369	.9437	.9909	.9990	.9999	1.000	1.000	.9090	1.18
12.	.7963	.9683	.9976	.9998	1.000	1.000	1.000	.9231	1.08
16.	.8819	.9991	.9999	1.000	1.000	1.000	1.000	.9412	1.00

TABLE VII.

Exponent $n''$ .	Ordinate Cross-sections $\mathcal{O}$ . for Displacement $\mathcal{M} = 1$ .							Displacement.	
	1	2	3	4	5	6	7	$v = \mathcal{M} L \times$	$t = \mathcal{M} L \times$
2.	.0545	.1914	.3713	.5625	.7381	.8909	.9688	.5333	.0152
2.25	.0673	.1795	.4260	.6236	.7919	.9135	.9671	.5663	.0162
2.5	.0805	.2512	.4772	.6777	.8352	.9383	.9889	.5952	.0170
2.75	.0944	.2987	.5262	.7247	.8697	.9563	.9934	.6204	.0177
3.	.1090	.3342	.5713	.7667	.8972	.9691	.9960	.6429	.0184
3.25	.1239	.3689	.6129	.7999	.9191	.9779	.9976	.6629	.0189
3.5	.1394	.4027	.6512	.8310	.9365	.9845	.9986	.6806	.0194
3.75	.1551	.4356	.6862	.8567	.9500	.9888	.9990	.6968	.0199
4.	.1712	.4673	.7181	.8789	.9608	.9922	.9994	.7111	.0203
4.5	.2039	.5270	.7736	.9146	.9751	.9956	.9996	.7264	.0211
5.	.2373	.5817	.8183	.9384	.9853	.9980	.9998	.7575	.0216
5.5	.2706	.6312	.8548	.9563	.9908	.9988	.9998	.7755	.0221
6.	.3038	.6757	.8844	.9688	.9944	.9995	.9999	.7924	.0227
6.5	.3366	.7155	.9078	.9780	.9966	.9996	.9999	.8047	.0230
7.	.3688	.7562	.9263	.9845	.9978	.9996	.9999	.8170	.0233
8.	.4309	.8080	.9540	.9920	.9992	.9998	1.000	.8366	.0239
9.	.4890	.8554	.9710	.9970	.9996	.9998	1.000	.8521	.0244
10.	.5430	.8906	.9819	.9980	.9998	.9999	1.000	.8656	.0247
12.	.6341	.9375	.9934	.9996	.9999	.9999	1.000	.8861	.0253
16.	.7777	.9991	.9998	.9999	.9999	1.000	1.000	.9126	.0261

In this article it is intended to show the process by which some of the formulas are obtained. The whole system is based on the simple parabolic formulas  $y = \sqrt[n]{px}$ ,  $x = \frac{y^n}{p}$ ,  $p = \frac{y^n}{x}$ , and  $n = \frac{\log.p + \log.x}{\log.y}$

in which the parameter  $p$  is the gauge for the parabolas. In order to apply the formulas as direct as possible to the subject in question, it is best to make a gauge that will be ready at hand, by limiting the parabolas within the size of the vessel, when the limit  $x = b$ , and  $y = l$ ; see fig. 1, Plate I.

$$p = \frac{y^n}{x} = \frac{l^n}{b}, \quad y = l \sqrt[n]{\frac{x}{b}} \quad \text{and} \quad x = \frac{b y^n}{l^n},$$

in which the length and breadth of the vessel is the gauge for the parabolas.

Let us first find the formula 5, page 99, for the area of the load water-line.

We are now obliged to refer to the calculus, from which we know that the increment of the area of any plan figure bounded by a curved line and rectangular co-ordinates, is equal to the increment of the abscissa multiplied by the ordinate; which two latter are obtained from the formula of the curve.

$$x = \frac{b y^n}{l^n}$$

$$\text{Differential } dx = \frac{n b y^{n-1} dy}{l^n},$$

multiplying this by the ordinate  $y$ , we obtain the differential of the area  $a$ ,

$$da = y dx = \frac{n b y^n dy}{l^n},$$

of which the integral is the area  $a$ .

$$\int da = a = \int \frac{n b y^n dy}{l^n} = \frac{n b}{l^n} \int y^n dy,$$

$$a = \frac{n b}{l^n} \cdot \frac{y^{n+1}}{n+1},$$

but when we limit the area to the length  $y = l$ , we have

$$a = \frac{n b}{l^n} \cdot \frac{l^{n+1}}{n+1} = \frac{n b l}{n+1},$$

which gives one-quarter of the area of the water-line, but by taking the whole beam  $B$  and length  $L$ , the whole area will be

$$a = \frac{n B L}{n+1}.$$

The process is precisely the same for finding the formula 7, for the cross-section  $\mathfrak{A}$ , where  $d$  is inserted for  $l$ .

Let us now find the formula 9, for the displacement.

The least possible resistance to a vessel of a given displacement bounded within the given length, breadth, and depth, is when the square root of the cross-sections  $\varpi$  are ordinates in a parabola of the exponent  $n''$ ; in this case the ordinates are taken at right angle to the centre line, and the abscissa from  $\mathfrak{W}$ , or the ordinates should be  $\sqrt{\varpi} = b - x$ , in which it should be clearly understood that the exponent for the parabola of the water-line  $n$  need not be the same as  $n''$  for the ordinate cross-sections  $\varpi$ , but for simplicity of notation the two dots will be omitted in the following formulas, where  $n$  means  $n''$ .

From the calculus of cubature we know that any solid bounded by an irregular surface, its increment of solidity is equal to the increment of the abscissa, multiplied by the area of the ordinate cross-section. In this case  $y$  will be the abscissa.

$$\text{Formula 4. } \varpi = \mathfrak{W} \left(1 - \frac{x}{b}\right)^2$$

From the formula of a parabola we have

$$\text{Differential } dx = \frac{n b y^{n-1} dy}{l^n},$$

$$\text{and } dy = \frac{dx l^n}{n b y^{n-1}},$$

and for the displacement  $D$  we have

$$\text{Differential } dD = dy \varpi = \frac{\mathfrak{W} l^n \left(1 - \frac{x}{b}\right)^2 dx}{n b y^{n-1}}.$$

By integrating we have

$$\text{Displacement } \int dD = \int \frac{\mathfrak{W} l^n \left(1 - \frac{x}{b}\right)^2 dx}{n b y^{n-1}},$$

$$\text{but } y = l \sqrt[n]{\frac{x}{b}} = \frac{l x^{\frac{1}{n}}}{b^{\frac{1}{n}}} \text{ and } y^{n-1} = \frac{l^{n-1} x^{1-\frac{1}{n}}}{b^{1-\frac{1}{n}}},$$

this value of  $y^{n-1}$  inserted in the denominator of the integral, will be

$$D = \int \frac{\mathfrak{W} l^n b^{1-\frac{1}{n}} \left(1 - \frac{x}{b}\right)^2 dx}{n b l^{n-1} x^{1-\frac{1}{n}}} = \int \frac{\mathfrak{W} l \left(1 - \frac{x}{b}\right)^2 dx}{n b^{\frac{1}{n}} x^{1-\frac{1}{n}}},$$

$$\text{of which } D = \frac{\mathfrak{W} l}{n b^{\frac{1}{n}}} \int \frac{\left(1 - \frac{x}{b}\right)^2 dx}{x^{1-\frac{1}{n}}}, \quad . \quad . \quad . \quad a$$

$$\left(1 - \frac{x}{b}\right)^2 = 1 - \frac{2x}{b} + \frac{x^2}{b^2}, \text{ and}$$

$$\int \frac{\left(1 - \frac{x}{b}\right)^2 dx}{x^{1-\frac{1}{n}}} = \int \left( \frac{dx}{x^{1-\frac{1}{n}}} - \frac{2x dx}{b x^{1-\frac{1}{n}}} + \frac{x^2 dx}{b^2 x^{1-\frac{1}{n}}} \right).$$

$$\int \frac{dx}{x^{1-\frac{1}{n}}} = \int x^{\frac{1}{n}-1} dx = nx^{\frac{1}{n}},$$

$$\int -\frac{2x dx}{bx^{1-\frac{1}{n}}} = \int -\frac{2x^{\frac{1}{n}} dx}{b} = -\frac{2x^{1+\frac{1}{n}}}{b(1+\frac{1}{n})},$$

$$\int \frac{x^2 dx}{b^2 x^{1-\frac{1}{n}}} = \int \frac{x^{2+\frac{1}{n}} dx}{b^2} = \frac{x^{2+\frac{1}{n}}}{b^2(2+\frac{1}{n})},$$

By inserting these integrals in the formula  $\alpha$ , we have the displacement

$$D = \frac{\mathfrak{M} l}{n b^{1-\frac{1}{n}}} \left( n x^{\frac{1}{n}} - \frac{2x^{1+\frac{1}{n}}}{b(1+\frac{1}{n})} + \frac{x^{2+\frac{1}{n}}}{b^2(2+\frac{1}{n})} \right).$$

It is required to find a formula expressing the whole displacement from  $\mathfrak{M}$  to the stern or stem of the vessel, for which we can in the preceding formula make  $x=b$ , when

$$D = \frac{\mathfrak{M} l}{n b^{\frac{1}{n}}} \left( n b^{\frac{1}{n}} - \frac{2 b^{1+\frac{1}{n}}}{b(1+\frac{1}{n})} + \frac{b^{2+\frac{1}{n}}}{b^2(2+\frac{1}{n})} \right),$$

$$D = \frac{\mathfrak{M} l}{n b^{\frac{1}{n}}} \left( n b^{\frac{1}{n}} - \frac{2 b^{\frac{1}{n}}}{1+\frac{1}{n}} + \frac{b^{\frac{1}{n}}}{2+\frac{1}{n}} \right).$$

Rejecting the factor  $b^{\frac{1}{n}}$ , we have

$$D = \frac{\mathfrak{M} l}{n} \left( n - \frac{2}{1+\frac{1}{n}} + \frac{1}{2+\frac{1}{n}} \right).$$

The factor in the parenthesis will be

$$\frac{2n^2}{2n^2 + 3n + 1},$$

and we arrive to the final formula for the displacement, when taking the whole length  $L$ , and resuming the dots on the exponent  $n''$ ,

$$D = \mathfrak{M} L \frac{2n''}{2n'' + 3n'' + 1}.$$

This is the formula as it appears in "Nystrom's Treatise on Ship Building and Marine Engineering," which gives the same result as that in this *Journal*, page 99, or

$$\text{Formula 9.} \quad D = \frac{n'' \mathfrak{M} L}{(n''+1)(1+\frac{1}{2n''})}.$$

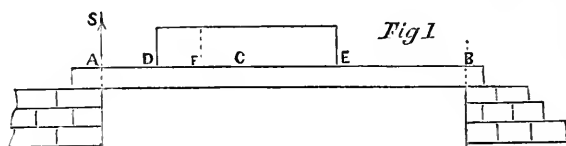
Such an operation is necessary for many formulas, which are apparently very simple when finished; the formulas, 11, 12, 13, and others, required each a more extensive operation, which shall be left for the reader to work out.

For the Journal of the Franklin Institute.

*Problems on Beams.*

By D. WOOD, M.A., Prof. Civil Eng., University of Michigan.

I find in *Weisbach's Mechanics and Engineering*, vol. i. p. 208, that when a beam is loaded over part of its length, the maximum moment—and hence the *dangerous section*—is assumed to be at the centre of the load. I find by investigation that this assumption is not correct.



Let  $l = AB$  = the length of the beam.

$2a = DE$  = length of the load, which is uniformly distributed over DE.

$c$  be the centre of the load.

$l_1 = AC$        $l_2 = CB$ .

$w$  = the load on a unit of length, say 1 inch.

$x = AF$  = the distance to any section.

$s$  = the re-action of the support.

Then

$$AD = l_1 - a \quad DF = x - AD = x - l_1 + a.$$

$$\text{Load on } DF = w(x - l_1 + a).$$

$$\text{“ } DE = 2wa.$$

By the principle of moments we have

$$sl = 2wa \cdot l_2 \quad \therefore \quad s = 2wa \frac{l_2}{l}.$$

Observing that the lever arm of the load on  $DF$  is  $\frac{1}{2} DF$ , we find that the moment of strain on the section at  $F$  is

$$sx - \frac{w}{2}(x - l_1 + a)^2,$$

$$\text{or, } \frac{2wal_2}{l}x - \frac{w}{2}(x - l_1 + a)^2 \quad \dots \quad (1)$$

which we wish to make a maximum. Differentiate and place equal zero, and we have

$$\frac{2wal_2}{l} - w(x - l_1 + a) = 0.$$

$$\text{We have also } l_1 + l_2 = l \quad \therefore \quad x = a \left( 1 - \frac{2l_1}{l} \right) + l_1 \quad \dots \quad (2)$$

Hence if  $l_1 < \frac{1}{2}l$  ;       $x > l_1$

$$l_1 = \frac{1}{2}l \quad \quad \quad x = l_1$$

$$l_1 > \frac{1}{2}l \quad \quad \quad x < l_1$$

So that the maximum strain is at the centre of the loading only when



the centre of the loading is over the middle of the beam; and in all other cases it is nearer the middle of the beam than the centre of the load is.

To find the maximum strain, substitute the value of  $x$ , Eq. (2), in expression (1).

Weisbach, vol. i. p. 209, gives the following example:

"What load may a hollow cast-iron beam sustain, if its outer depth and breadth be 8 inches and 4 inches, and inner depth and breadth 6 inches and 2 inches; and if, further, the middle of the load, uniformly distributed over 3 feet in length, is distant from one support 4, and the other 2 feet?"

If  $\frac{1}{8}R = 1000$  lbs., we shall have, for the strength of the *dangerous section*, from the well known formula,

$$\frac{1}{8}R \frac{bd^3 - b_1d_1^3}{d} = 1000 \frac{4 \times 512 - 2 \times 216}{8} = 202000.$$

On the hypothesis that the *dangerous section* is at the centre of the loading, we make  $x = l_1$  in (1), which reduces it to  $\frac{2wal_1l_2}{l} - \frac{wa^2}{2}$  which must equal 202000, or by substituting  $l_1$ ,  $l_2$  and  $a$  we have  $23wa = 202000$ .

$\therefore 2wa = 17565$  lbs. as found by Weisbach.

But from Eq. (2) we find that the *dangerous section* is

$$x = \frac{2}{3} \left( 1 - \frac{2}{3} \right) + 2 = 2\frac{1}{3} \text{ ft.} = 30 \text{ inches from A.}$$

This substituted in (1) gives

$$432w = 202000$$

$$\therefore w = \frac{202000}{432}$$

$$\therefore 2aw = 36w = \frac{202000 \times 36}{432} = 16833 \text{ lbs.}$$

Hence Weisbach's hypothesis gives too much by  $17565 - 16833 = 732$  lbs., which is only a little more than 4 per cent. too much; a quantity which is fully provided for in the small co-efficient for rupture.

From Eq. (2) we see that the distance between the centre of the loading and the section of maximum strain is

$$x - l_1 = a \left( 1 - \frac{2l_1}{l} \right) \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Let  $AD = y = l_1 - a \therefore a = l_1 - y$ , which substituted in (3) gives

$$x - l_1 = (l_1 - y) \left( 1 - \frac{2l_1}{l} \right)$$

which is evidently a maximum for  $y = 0$ , hence Eq. (3) is a maximum so far as the distance  $AD$  is concerned, when it ( $AD$ ) is zero; or when one end of the load is over the support. For this condition  $a = l_1$ , which reduces (3) to

$$x - l_1 = l_1 \left( 1 - \frac{2l_1}{l} \right) \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Now, consider  $l_1$  as the variable, and we find that (4) is a maximum

for  $l_1 = \frac{1}{4}l$ ; or,  $2l_1 = \frac{1}{2}l$ ; or the load must extend to the middle of the beam. For these conditions make  $a = l_1 = \frac{1}{4}l$  in (3), (2), and (1), and we have

$$x - l_1 = \frac{1}{8}l$$

$$x = \frac{3}{8}l.$$

The maximum moment Eq. (1) is  $= \frac{9}{128}wl^2 = w\frac{1}{2}l \times \frac{9}{64}l = \frac{9}{64}wl$ , in which  $w$  is the total load on one-half the beam.

The strain at the middle of the loading, when the load extends from one end to the middle of the beam, is  $\frac{1}{8}wl$ ; hence, the maximum strain is  $\frac{9}{64}wl \div \frac{1}{8}wl = 1\frac{1}{8}$  times that at the middle of the loading, when the load extends from one support to the middle of the beam.

*Of the Beam fixed at both ends, and a load midway between the fixed points.*

Much has been said upon this case, on account of the discrepancy between theory and the results of experiment. Those who are familiar with the analytical solution of the problem, know that analysis shows that the beam is equally liable to break at the middle and at the ends, and that the moment of the strain at each of these three points is  $\frac{1}{8}Pl$ , in which

$P$  = the load at the middle.

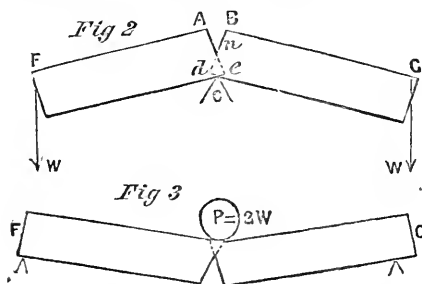
$l$  = the distance between the fixed points.

If the beam be supported at its ends, the strain would be  $\frac{1}{4}Pl$ ; hence the strains are as 2 to 1.

Barlow, in his Treatise on the Strength of Materials, pp. 35 and 138, says their strengths are to each other as 3 to 2.

On pages 125 and 126 of the same work, he explains how the experiments were made.

I do not propose to solve the problem, but make these remarks for those who are familiar with it. Barlow, in the work referred to, attempts a solution in which he deduces the ratio already given, viz: 3 to 2, but I think an error has crept into his reasoning, which I will proceed to point out. He says (Art. 53) "it is shown that it requires four times the weight to produce the same deflection in the beam supported at each end, as is requisite to produce the same quantity in a beam of half the length."



By referring to Article 35, I find that he arrives at this conclusion by assuming that in the deflection the fibres are nowhere elongated or compressed, except those directly over the support  $c$ , fig. (2); or under the weight  $P$ , fig. (3). With this view, his conclusion is correct: but the view is erroneous. For all the fibres from  $A$  to  $a$ , on one side, are elongated; and, on the other, compressed. During

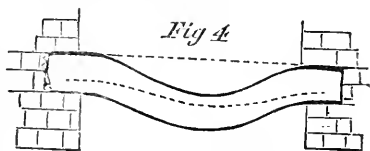
flexure there is no such opening as  $AnB$ , as is represented in the figure. It is one of the fundamental principles of flexure, that sections which are normal to the axis of the beam before flexure, will be normal to the neutral axis after flexure; hence, the surfaces  $Ac$  and  $Bd$  coincide and remain in a vertical plane. With this view of the question, the preceding quotation should read: "It requires twice the weight, &c." And then Barlow would obtain the same results as other theorists.

But now arises the real difficulty. Barlow records a series of experiments (p. 138 of his work) on beams whose ends are fixed in a wall, and it appears from these that the ratio should be nearly as 3 to 2. He tries to explain the discrepancy, by assuming that the case investigated by theorists is different from the one under consideration, inasmuch as *they* suppose that the beam is extended beyond the support, and the beam is *fixed* by a force sufficient to make the tangent to the curve horizontal over the support. The fallacy which he introduced in the problem of the deflection of a beam supported at its ends, has entered into this; and the explanation which I have made of the former is applicable to the latter.

We are, moreover, confirmed in our view that the two cases which Barlow mentions, are essentially the same, from the fact that a beam which has one end fixed in a wall, and the other acted upon by a force, gives the same results as a beam of double the length supported at the middle, and acted upon at each end by the same force.

M. Navier, in his *Résumé des Leçons sur l'Application de la Mécanique*, p. 189, remarks: "It is difficult, in experiments to realize the hypothesis of fixedness at the extremities." Also, "The reaction of the supports, as shown by theory, will be infinite, if the prolonged part be zero." This probably states the greatest difficulty, but it may be nearly, if not quite, overcome by a method suggested by Mr. Cooper, p. 195, vol. xli, 3rd series of this *Journal*. His suggestion is to extend the beam over several supports, and load it with a weight,  $P$ , midway between each.

There is, however, one element in this problem which does not enter into that of a beam supported at the ends, and which has not, so far as I know, received any attention. It is the stretching of the neutral axis. In the analysis we assume that the neutral axis retains its original length during flexure; but it is evident that if the ends be *fixed*, no flexure can take place without elongating the axis. For this reason the neutral axis cannot coincide with the axis of the beam, but inclines to the concave side throughout, as shown in fig. (4). So much of the force as is absorbed in producing this elongation, must be subtracted from the modulus of rupture, in determining the moment of resistance. This elongation will be small, but it should not be neglected in comparing theory with experiment.



Inasmuch as the resistance to flexure varies inversely as *the cube of the depth*, and the strength directly as *the square of the depth*, I would

suggest, that in applying Mr. Cooper's method, the depth of the beam be large compared with the breadth, so as to make the deflection small, and thus stretch the neutral axis as little as possible.

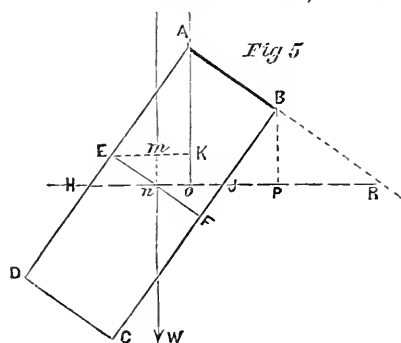
*Of the strength of a rectangular beam when the force is not applied perpendicular to either surface.*

Writers upon the strength of beams usually assume that when a beam is subjected to a force which is inclined to its side, the neutral surface is perpendicular to the direction of the force. This does not appear to me to be true in all cases, for when the beam is thin and considerably inclined, it will break by being deflected sidewise, and not wholly in the direction of the force. But in practical cases a thin beam would not be so placed as to have its sides inclined to the direction of the force, and if the beam were nearly square, the deviation from the ordinary hypothesis must be small. In all cases, whether the beam be very narrow compared with its depth, or nearly square—if the direction of the force coincides with the diagonal of the section, the neutral surface will, I think, be perpendicular to the direction of the force. Suppose, then, that

*A rectangular beam is acted upon by a force which is inclined to its sides, it is required to find its strength in all positions; also its inclination for a maximum and minimum strength—in all cases assuming that the neutral surface is perpendicular to the direction of the force.*

I will suppose that the force is vertical and the beam inclined.

Let ABCD be the section, HJ the neutral axis, angle AHJ =  $x$ .



$I$  = moment of inertia of the section.

$d_1 = AO$  = distance of most remote fibre from the neutral axis.

$R$  = modulus of strength.

$d = AD$        $b = AB$ .

Then

$\frac{I}{R d_1}$  = the strength of the beam at this section.

The moment of inertia of the whole section is twice the moment of AHJB, and the moment of AHJB is equal to the moment of the triangle HAR minus the moment of BJR. The moment of inertia of the triangle AHR about its base HR, is  $\frac{1}{12} (HR) \times (AO)^3$ , that of BJR is  $\frac{1}{12} (JR) \times (BP)^3$ .

Let  $k_1$  = area AHR.

$k_2$  = area BJK.

$d_2$  = BP.

$k$  = area AHJB.

Then the moment of inertia of  $ABJH$  becomes

$$\frac{1}{12} IR \cdot d_1^3 - \frac{1}{12} JR d_2^3 = \frac{1}{6} [k_1 d_1^2 - k_2 d_2^2] \quad (1)$$

Because of the similarity of triangles, we have

$$k_1 : k_2 :: d_1^2 : d_2^2 \therefore k_2 = \frac{k_1 d_2^2}{d_1^2}$$

also,  $k_1 - k_2$ , or  $k : k_1 :: d_1^2 - d_2^2 : d_1^2$ .

These reduce (1) to  $\frac{1}{6} k (d_1^2 + d_2^2)$  . . . . . (2)

But  $d_1 = AK + KO = \frac{1}{2} d \sin. x + \frac{1}{2} b \cos. x$  . . . . . (3)

$$d_2 = \frac{1}{2} d \sin. x - \frac{1}{2} b \cos. x$$

These substituted in (2) give

$$\frac{1}{12} k (d^2 \sin.^2 x + b^2 \cos.^2 x)$$

And the moment of the whole area becomes

$$I = \frac{1}{12} 2 k (d^2 \sin.^2 x + b^2 \cos.^2 x) = \frac{1}{12} bd (d^2 \sin.^2 x + b^2 \cos.^2 x) \quad (4)$$

Equations (3) and (4) give

$$R \frac{I}{d_1} = \frac{1}{6} R \frac{b d (d^2 \sin.^2 x + b^2 \cos.^2 x)}{d \sin. x + b \cos. x} \quad (6)$$

This is the result reached by all analysts.

If  $x = 90^\circ$  Eq. (6) becomes  $\frac{1}{6} R b d^2$

"  $x = 0$  " " " "  $\frac{1}{6} R b^2 d$ .

To find the inclination so as to give a minimum strength, make the first differential co-efficient of Eq. (6) equal zero. This gives  $0 =$

$$(d^3 - 2b^2 d) \sin.^2 x \cos. x + (2bd^2 - b^3) \sin. x \cos.^2 x + b d^2 \sin.^3 x - b^2 d \cos.^3 x.$$

But  $\sin.^3 x = \sin. x (1 - \cos.^2 x)$  and  $\cos.^3 x = \cos. x (1 - \sin.^2 x)$  which will reduce the preceding equation to

$$(d^3 - b^2 d) \sin.^2 x \cos. x + (bd^2 - b^3) \sin. x \cos.^2 x + b d^2 \sin. x - b^2 d \cos. x = 0.$$

In this substitute  $\sin. x = \sqrt{1 - \cos.^2 x}$  and reduce, and we obtain  
 $[-(bd^2 - b^3)^2 - (d^3 - b^2 d)^2] \cos.^6 x + [(bd^2 - b^3)^2 - 2(bd^2 - b^3)b d^2 - 2(2bd^2 - d^3)(d^3 - b^2 d)] \cos.^4 x + [2(bd^2 - b^3)b d^2 - b^2 d^4 - (2b^2 d - d^3)^2] \cos.^2 x = -b^2 d^4$  . . . . . (7)

### Discussion of Equation (7)

1. Let  $d = nb$ ; then we have

$(n^6 - n^4 - n^2 + 1) \cos.^6 x - (2n^6 - 7n^4 + 4n^2 + 1) \cos.^4 x + (n^6 - 5n^4 + 6n^2) \cos.^2 x = n^4$  (8); hence the angle depends only upon the ratio of the sides.

2. Let  $n = 1$ .

This reduces Eq. (8) to  $\cos.^2 x = \frac{1}{2}$ .

$$\therefore \cos. x = \pm \sqrt{\frac{1}{2}}. \therefore x = 45^\circ \text{ or } 135^\circ$$

These values in Eq. (6) give

$$\frac{1}{6} R \frac{b^3}{\sqrt{2}} = \frac{1}{6} R b^3 \times 0.70710 +, \text{ for the strength of the beam.}$$

If  $b = d$  and  $x = 90^\circ$  in Eq. (6) we find  $\frac{1}{6} R b^3$  for the strength of the beam.

Hence the strength of a square beam with its side vertical, is to the

strength of the same beam with its diagonal vertical as 1 to 0.70710. But if the condition be that the beam shall in both cases be completely severed, then the latter fraction must be multiplied by 1.09125 +, as shown in my article on triangular beams, in vol. xli. p. 201 of this *Journal*. Then the ratio becomes as 1 to 0.77162 +.

3. Let  $n=2$  and  $\cos.^2 x = y$

Then Eq. (8) will reduce to

$$y^3 - \frac{3}{4}y^2 + \frac{8}{5}y = \frac{1}{45} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

To make the second term disappear, make  $y = z + \frac{1}{45}$ , and substitute in Eq. (9), which reduces it to

$$z^3 - \frac{3}{45}z = \frac{31102}{45^3}$$

This solved gives  $z = 0.70112 +$

$$\therefore y = 0.94556 + = \cos.^2 x$$

$$\therefore \cos. x = + 0.9723 +$$

$$\therefore x = 13^\circ 30' \text{ or } 166^\circ 30'$$

making  $d=2b$  in Eq. (6), we have for the strength of the beam when  $x = 13^\circ 30'$  ;  $\frac{1}{3} R b^3 \times 0.8295 +$

$$\text{" } x = 0^\circ \quad ; \quad \frac{1}{3} R b^3$$

$$\text{" } x = 90^\circ \quad ; \quad \frac{2}{3} R b^3$$

It is probable that in the inclined position, the angle would fracture before the beam is loaded to its ultimate strength, but the investigation for determining it would be tedious and unprofitable. Whether this be the case or not, we see that the beam is not weakest when it rests on its broad side.

The other two roots of Equation (9) are imaginary; hence, the equation does not indicate the position of maximum strength. This is because the value of Eq. (9) increases as  $y$  increases indefinitely; but all possible inclinations of the beam are included between  $\cos.^2 x = y = 0$  and  $\cos.^2 x = y = 1$ , the former of which gives the position of greatest strength when  $d$  is greater than  $b$ ; and the latter when  $b$  is greater than  $d$ .

We might proceed to make other suppositions on  $n$ , but enough has already been given to illustrate the mode of procedure. Equation (8) can be solved for all possible values of  $n$ , for it is of the form of a cubic equation.

3. If  $n$  is infinite, we may omit all the inferior powers in each factor in Eq. (8) and thus obtain

$$n^6 \cos.^6 x - 2n^6 \cos.^4 x + n^6 \cos.^2 x = n^4$$

$$\text{or } \cos.^6 x - 2 \cos.^4 x + \cos.^2 x = \frac{1}{n^2} = \frac{1}{\infty^2} = 0$$

the roots of which are

$$\cos. x = 0^\circ \quad \cos. x^2 = + 1$$

$$\therefore x = 90^\circ \quad x = 0^\circ \text{ or } 180^\circ$$

The former value of  $x$  gives the position for maximum; the latter, for minimum. This is the case of a very thin beam.

4. Let  $n = 0$ . This is also the case of an infinitely thin beam, but  $b$  is the greater quantity. Eq. (8) becomes

$$\begin{aligned}\cos.^6 x - \cos.^4 x &= 0 \\ \therefore \cos. x &= 0 \text{ or } \cos.^2 x = 1 \\ \therefore x &= 90^\circ \text{ or } x = 0^\circ \text{ or } 180^\circ\end{aligned}$$

the former of which gives the position for a minimum, and the latter for maximum strength.

It appears that the side of the beam may be so inclined as to have the same strength as when it rests on its broad side, and the angle of inclination which will fulfil this condition, may be found by making Eq. (6) equal  $\frac{1}{6} R b^2 d$ .

This done,  $\cos. x$  eliminated, and a reduction made, gives ;

$$(d^2 - b^2)^2 \sin.^3 x - 2 (d^2 - b^2) b d \sin.^2 x + (3 b^2 d^2 - b^4) \sin. x = 2 b^3 d$$

If  $d = n b$ , we have

$$(n^2 - 1)^2 \sin.^3 x - 2 (n^2 - 1) n \sin.^2 x + (3 n^2 - 1) \sin. x = 2 n.$$

If  $n = 2$ , we have

$$\sin.^3 x - \frac{4}{3} \sin.^2 x + \frac{11}{9} \sin. x = \frac{4}{9}$$

Make  $\sin. x = y$  and  $y = z + \frac{4}{9}$  and we have

$$z^3 + \frac{5}{3} z = \frac{56}{9^3}$$

which solved by Cardan's formula gives

$$\begin{aligned}z &= 0.11929 \therefore y = 0.56473 = \sin. x \\ \therefore x &= 34^\circ 23' .\end{aligned}$$

To prove the truth of the result, substitute this value of  $x$  in Eq. (6). The other two roots are imaginary.

Translated for the Journal of the Franklin Institute.

### *Restoration of Old Wood-cuts.*

The French Journals speak of an invention by M. Coblence by which "is restored to the most worn out wood-cuts all its primitive sharpness, and it can be electrotyped as perfectly as a new one." The means by which this is done are not yet published, but the editor of one of the Journals certifies that he has seen the proofs taken from the *clichés* thus made, and that they have all the sharpness of first proofs, although the blocks had been used for a great number of editions.

The value of such a discovery, if there be any truth in it, can hardly be over-estimated.

### *On Eight Scientific Balloon Ascents.* By MR. GLAISHER.

From the London Athenaeum, Oct., 1862.

The author first said, all philosophical inquiries carried on near the surface of the earth, are, of necessity, fully within its influence, and, consequently, of many disturbing causes. All experiments thus conducted are affected by radiation ; conduction and reflection of heat ; of reflection of rays of light, of currents of air, of the effect of large or small

evaporating surfaces on the one hand, or of large or small condensing surfaces on the other; and of many other disturbing causes, all of which are sources of error, and from the effect of which we cannot escape even by going to the top of the highest mountains. By no other means than by the use of the balloon can we free ourselves from these disturbing influences; and the question has often been asked, particularly since the formation of the British Association, whether or not the balloon affords a means of accomplishing with advantage the solution of many questions in physics which are seriously affected by them?—whether, for instance, delicate and accurate observations can be made by these?—whether an observer in such a position can be at his ease, so as to be able to observe as well as on the earth?—whether these observations can be made with tolerable safety to himself, &c.? To answer these questions, it was necessary to ascend in a balloon; and it seemed to Mr. Glaisher that their solution was well worth the venture. The author then said, let us consider for a moment what science would be benefited from experiments under the circumstances of being free from so many sources of error. These are, meteorology and astronomy, and all allied sciences, certainly; chemistry and magnetism, &c., probably. Perhaps, of all branches of physical research the greatest advantage would accrue to meteorology and to astronomy; and when we regard the influence which a clear sky or a cloudy one exercises on the temperature and weather, and what an important part the condition of the sky exercises upon our comfort and well-being generally, there seems to be a high probability that by studying the laws which govern the higher strata of the air, and cultivating some acquaintance with these regions themselves, our knowledge of aerial phenomena could be greatly increased: and with regard to astronomy, there is no more important point in the whole range of physical research, to which experiments can be devoted, than to improving our knowledge of the laws of refraction, when it is recollected that the true position of every heavenly body is dependent upon our correct knowledge of these laws. He then detailed the object of the experiments as follows:—The primary objects of the experiments were—the determination of the temperature of the air and its hygrometric state at different elevations, up to 5 miles. The secondary objects were—to compare the readings of an aneroid barometer with those of a mercurial barometer up to 5 miles; to determine the electrical state of the atmosphere; to determine the oxygenic condition of the atmosphere by means of ozone papers; to determine the time of vibration of a magnet on the earth and at different distances from it; to determine the temperature of the dew-point by Daniell's dew-point Hygrometer and Regnault's Condensing Hygrometer, and by the use of the dry and wet bulb thermometers as ordinarily used, and by their use when under the influence of the aspirator, so that considerable volumes of air were made to pass over both bulbs at different elevations, as high as possible, but particularly up to those heights where man may be resident, or where troops may be located, as in the high lands and plains of India, with the view of ascertaining what confi-



dence may be placed in the use of the dry and wet bulb thermometers at those elevations, by comparison with those found directly by Daniell's and Regnault's Hygrometers, and also to compare the results as found by the two Hygrometers together: to collect air at different elevations; to note the height and kind of clouds, their density and thickness at different elevations; to determine the rate and direction of different currents in the atmosphere, if possible; to make observation on sound; to note atmospherical phenomena in general, and to make general observations. The instruments used consisted of mercurial and aneroid barometers; dry and wet bulb thermometers, also an exceedingly sensitive thermometer; Daniell's Dew-point Hygrometer; Regnault's Condensing Hygrometer; solar radiation thermometer; maximum and minimum thermometers; a small magnet for horizontal vibrations, hermetically sealed, and exhausted glass-tubes; ozone test-papers, &c. - All the instruments were constructed by Messrs. Negretti & Zambra, excepting the mercurial barometer, which was entrusted to Mr. P. Adre, of London. He then detailed the instruments, the observing arrangements, and the circumstances of the ascents, of which three were made from Wolverhampton, on July 17, August 18, and September 5; four from the Crystal Palace, viz: on July 30, August 20, September 1, and September 8; and one from Mill Hill, near Hendon, where the balloon had fallen the night before, and where it had been anchored during the night. In the ascent on July 17, a height of 26,177 feet was reached; and in the descent a mass of vapor of 8000 feet in thickness was passed through, so dense that the balloon was not visible from the ear. In that of August 18, an altitude of 11,500 feet was attained: then the balloon descended to 3200 feet; then ascended to 23,400 feet, where a consultation took place, and it was decided not to go higher, as clouds of unknown thickness and moisture had to be passed through. In the ascent on August 20, the air was almost calm; the balloon for a long time hovered over the Crystal Palace, and then over London, whilst it was lighted up, where they seemed to be destined to remain all night; finally, went above the clouds, and came down at night near Hendon. The balloon was then anchored for the night, the lower valve being closed with the hope that the gas would be retained. Before sunrise, on August 21, all the instruments were replaced and the balloon left the earth. It was a warm, dull, cloudy morning; clouds were reached at the height of 5000 feet; the light rapidly increased, and gradually the balloon emerged from dense clouds into a basin surrounded with immense black mountains of cloud, rising far above; shortly afterwards there were deep ravines of grand proportions below, bounded with beautiful curved lines. The sky was blue with cirri. The tops of the mountain-like clouds became silvery and golden; at the height of 8000 feet we were on their level, and the sun appeared flooding with golden light all space for many degrees, both right and left, tinting with orange and silver all the remaining space. It was a glorious sight. As the sun's rays fell on the balloon we rose more

rapidly, each instant opening to us ravines of wonderful extent, and presenting elsewhere a mighty sea of cloud. Here there were shining masses in mountain chains, some rising perpendicularly from the plains, dark on one side, and silvery and bright on the other, with summits of dazzling whiteness; some there were of a pyramidal form, a large portion undulatory, and in the horizon Alpine ranges bounded the view. A height of nearly three miles was reached. On Sept. 1, when at the height of three-quarters of a mile over London, the whole course of the river Thames was visible from its mouth; and parallel to it, and bounded by its banks, a cloud or fog-bank extended the whole distance, following all its sinuosities. For half an hour before the descent, near Woking, in Surrey, the balloon was under one stratum of cloud and above another; the upper surface of the latter was remarked as bluish white, the middle portion the pure white of the cumulus, and the lower surface a blackish white, and from which rain was falling on the earth. The balloon descended to a height of 1300 feet, but still above these clouds. It was afterwards learnt that rain had been falling from these clouds all the afternoon. On Sept. 5, the balloon ascended from Wolverhampton: at 29,600 feet from the earth Mr. Glaisher became insensible; the balloon still ascended to fully the height of 35,000 feet or 36,000 feet, and may have gone even higher. Mr. Glaisher recovered his consciousness on descending, when at about the same height he lost it on ascending. The author had prepared and exhibited diagrams showing the path of the balloon and temperatures of the air at different elevations for each ascent, and extensive tables of all his observations. From these he deduced the following table, showing the mean temperature of the air at every 5000 feet of elevation above the level of the sea in each high ascent:—

Height above the level of the Sea.	Mean Temperature of the Air.					Decrease of Temperature for an increase of height of 5000 feet.
	July 17.	August 18.	August 21.	September 5.	Mean.	
Feet.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
0	61·2	69·6	62·0	62·2	63·8	
5,000	39·7	48·0	43·3	41·4	43·1	20·7
10,000	28·0	40·7	32·0	31·0	32·9	10·2
15,000	31·0	31·1	19·0	21·0	25·7	7·2
19,500	42·2					
20,000	33·0	25·9		10·6	23·2	2·5
25,000	16·0	23·9		0·0	13·3	9·9
30,000				-5·3		
Decrease of Temperature for an increase of height of 25,000 feet,	44·9	45·7		62·2	50·5	

The results on July 17 are perfectly anomalous. Up to 10,000 feet

the decrease accords with the other days of experiments; but from 10,000 feet the results are perfectly surprising, and continue so up to more than 20,000 feet. Above 25,000 feet they are again accordant. If we suppose that up to 10,000 feet and again to 25,000 feet the results are not abnormal, by continuing the curve joining these two portions, and then reading, we should have the following readings, viz:—at 0 ft. the mean temperature was  $61^{\circ} \cdot 2$ ; at 5000 feet,  $39^{\circ} \cdot 7$ ; at 10,000 feet,  $27^{\circ} \cdot 5$ ; at 15,000 feet,  $22^{\circ} \cdot 7$ ; at 19,500 feet,  $20^{\circ} \cdot 0$ ; at 20,000 feet,  $19^{\circ} \cdot 5$ ; at 25,000 feet,  $16^{\circ} \cdot 3$ . Then the measure of disturbance would be as follows:—At 10,000 feet,  $0^{\circ} \cdot 5$  in excess; at 15,000 feet,  $8^{\circ} \cdot 3$  in excess; at 19,500 feet,  $22^{\circ} \cdot 2$  in excess; at 20,000 feet,  $13^{\circ} \cdot 5$  in excess; at 25,000 feet,  $0^{\circ} \cdot 3$  in defect. The numbers in the last column of the table show that the average decrease of temperature in the first 5000 feet exceeds  $20^{\circ}$ , and in the next 5000 feet is but little more than  $10^{\circ}$ . The numbers in the lowest line of the table show that the average decrease of temperature for 25,000 feet is  $51^{\circ}$  nearly. From these numbers it seems that two-fifths of the whole decrease of temperature in 5 miles takes place in the first mile, and therefore that the decrement is not uniform with the increment of elevation. The author then discussed the observations up to 1 mile in all the eight ascents. The following table shows the mean temperature of the air at every 1000 feet up to 5000 feet on the days of the balloon's ascent:—

Height.	July 17.	July 30.	Aug. 18.	Aug. 20.	Aug. 21.	Sept. 1.	Sept. 5.	Sept. 8.	Mean.	Effect of 1000 ft.
Feet.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
0	61·2	70·0	69·6	66·8	62·0	67·0	62·2	69·7	66·1	
1000	57·0	63·0	62·0	62·0	58·0	59·8	57·8	65·0	60·6	5·5
2000	52·6	56·8	56·5	57·0	54·0	53·2	55·0	60·4	55·4	5·2
3000	48·3	52·2	53·3	52·7	50·3	49·2	48·7	55·7	51·3	4·1
4000	44·0	49·8	50·4	49·0	46·9	47·7	45·0	51·5	48·0	3·3
5000	39·7	47·0	48·0	45·0	43·3	46·0	41·4	48·4	44·8	3·2
Effect of an elevation of 5000 feet,	21·5	23·0	21·6	21·8	18·7	21·0	20·8	21·3	21·3	

From this table we learn that the mean decrease of temperature of the air exceeds  $21^{\circ}$  for the first mile, and from the last column that the rate of the decrease of temperature in the atmosphere is not uniform up to 5000 feet. These results are based upon observations including clear and cloudy states of the sky: in the former the differences would be larger, and in the latter they would be smaller. The author then spoke upon the electrical state of the air, which he found charged with positive electricity, decreasing in amount with elevation. With respect to ozone, he said none was shown in the earlier ascents, but that large quantities were shown in the latter, and attributed the deficiency in the former to bad paper. He remarked, that diminished pressure exercised a very different influence upon different individuals, dependent probably upon temperament and organization; that the effect of high elevation was different upon the same individual at different times; that the time of the vibration of a magnet was somewhat longer

at high elevation than on the earth; that different notes and sounds pass more readily through the air than others, instancing that the barking of a dog can be heard two miles high, and the shouting of a multitude not one mile. The author concluded his paper with the following remarks :

These eight ascents have led me to conclude, Firstly, that it was necessary to employ a balloon containing nearly 90,000 cubic feet of gas, and that it was impossible to get so high as 6 miles, even with a balloon of this magnitude, unless carburetted hydrogen, varying in specific gravity from 370 to 340, had been supplied for the purpose. It is true that these statements are rather conflicting when compared with those made by one or two early travelers, who professed to have reached some miles in height with small balloons. But if we recollect that at 3½ miles high a volume of gas will double its bulk, we have at once a ready means of determining how high a balloon can go; and in order to reach an elevation of 6 or 7 miles, it is obvious that one-third of the capacity of the balloon should be able to support the entire weight of the balloon, including sufficient ballast for the descent. The amount of ballast taken up affords another clue as to the power of reaching great heights. Gay-Lussac's ballast, as before mentioned, was 33 lbs. Rush and Green, when their barometers, as stated by them, stood at 11°, had only 70 lbs. left; and this was considered sufficient *playing* power. We found that it was desirable to reserve 500 or 600 lbs.; and although we could have gone much higher by saving less, still on every occasion it was evident that a large amount of ballast was indispensable to regulate the descent and select a favorite spot with the nicest accuracy. Secondly, it was manifest throughout our various journeys, that excessive altitude and extended range as to distance are quite incompatible. The readings of the instruments establish this; and it has been pointed out what a short time the balloon held its highest place, and how reluctantly it appeared to linger even at a somewhat less elevation. This was not owing to any leakage or imperfection in the balloon itself, for its efficiency has been well tested, and it remained intact a whole night without the least perceptible loss of gas. It has been stated by an aéronaut of experience that strong opposing upper currents have been heard to produce an audible contention, and to sound like the "*roaring of a hurricane.*" Now, the only deviation we experienced from the most perfect stillness, was a slight whining noise in the netting, and this only when the balloon was rising with great rapidity. The balloon itself, as it descends, flaps about occasionally; but this occurs when it is in a collapsed state, and very likely it was under similar circumstances, and perhaps during a rapid descent, that the flapping of the lower part of the balloon was mistaken for a roaring wind. I may also state that the too readily accepted theory as to the prevalence of a settled west or northwest wind was not confirmed in our trips; nor was the appearance of the upper surface of the clouds such as to establish the theory, that the clouds assume the counterpart of the earth's surface below, and rise or fall like hills and dales. The formation of vapor along the course, and during an ascent from the Crystal Palace, has already

been alluded to; this was a very remarkable demonstration. The principal results deduced from these observations may be briefly stated. That the temperature of the air does not decrease uniformly with height above the earth's surface, and that, consequently, more elucidation upon this point is required, particularly in its influence on the laws of refraction. That an aneroid barometer can be made to read correctly, certainly to the first place, and probably to the second place of decimals, to a pressure so low as 5 inches. That the humidity of the atmosphere does decrease with the height, with a wonderfully increasing rate, till at heights exceeding 5 miles, the amount of aqueous vapor in the atmosphere is very small indeed. That we now can answer the question I put in my opening remarks, and can say that observations up to 3 miles high, even of a delicate nature, can be made as comfortably in a balloon as on the earth; that at heights exceeding 4 miles they cannot be made quite so well, because of the personal distress of the observer; that at 5 miles high it requires the exercise of a strong will to make them at all. That up to 3 miles high any person may go in the car of a balloon who is possessed of an ordinary degree of self-possession. That no person with heart disease or pulmonary complaints should attempt 4 miles high. But, at the same time, it must be borne in mind that I am concluding that the balloon is properly handled. It has been fortunate for this Association and myself that we have had the assistance of Mr. Coxwell, who has the experience of more than 400 ascents, based upon knowledge of natural philosophy, and that he knows "the why and because" of all his operations; and it was this fact, which I saw immediately from the clearness of his explanation to me for each operation, that enabled me to dismiss from my mind all thoughts of my position, and to concentrate my whole energies upon my duties. In conclusion, I feel certain that if these experiments prove that the balloon is available for philosophical research, then one of the brightest links in the long chain of useful works, performed through the agency of the Association, will be the feeling that the balloon, in proper hands, may be made a powerful philosophic agent.

Proceedings Brit. Assoc.

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For the Journal of the Franklin Institute.

*Report on the Oil District of Oil Creek in the State of Pennsylvania.*

By THOMAS S. RIDGWAY, Geologist and Mining Engineer, of Cambridgeport, Mass., late Geologist to Maj. Gen. JOHN C. FREMONT in his Military Campaign in Western Virginia.

The oil district of Oil Creek in the State of Pennsylvania is situated in a shallow geological basin (sinclinal trough) whose bearing is nearly north and south, and yet having a gentle inclination in a southerly direction.

The strata of rock drilled into along the margin of Oil Creek are the Vergent Series of Prof. Rogers composed of compact close-grained

white and gray flaggy sandstones, alternating with red and olive-colored argillaceous shales. The beds of white and gray sandstones have been numbered by the drillers for oil on Oil Creek in the descending order Nos. 1, 2, 3, 4, and 5, commencing in the bottom land on Oil Creek below Titusville. This numbering answers very well along the margin of the streams in Venango County, but in the County of Crawford there is an important bed of sandstone to drillers laying above No. 1, and reposes immediately under the town of Titusville, which I shall name the Titusville bed, and another above this found back in the hills which I shall call the Quarry bed. There is also a group of beds of soft micaceous sandstones found overlaying the tops of the hills in the vicinity of Titusville, which I shall name the Top Group of Rocks of the Oil Bearing Strata. This group is capped in some places by the Vespertin Conglomerate Rocks of Prof. Rogers.

Here we have a mass of Oil Bearing Strata of about 1200 feet in thickness largely saturated with petroleum from the Vespertine Conglomerate down to the Genesee slates. A formation very little disturbed from its original nearly horizontal position, save the slight swells and depressions crossing the oil trough obliquely. The molten plutonic waves which broke up the crust of the earth in northern Pennsylvania appear to have died out and rounded out towards the lakes, for one does not find here the huge anticlinal and sinclinal axial lines as in central Pennsylvania, but instead, feeble lines of elevation and depression crossing an original trough or basin of the Devonian Sea. In proof of this, I find the Oil Bearing Strata broken up into huge cakes of sandstones and shales, having fissures or openings between the strata extending down to a great depth, and which are generally found filled with gravel and pebbles, the result of the Drift Formation. These openings are numerous in the valley of Oil Creek, and the cause of much perplexity to drillers in search of oil. Parties sinking test holes for oil have driven iron pipe (a process which obviates boring through sand and gravel to the rock) down into some of these openings to the surprising depth of 160 feet from the surface of the country before striking the permanent rock, whilst their neighbors only a few yards distant have reached the horizontal strata at a depth of 30 or 40 feet. On Samuel Machintire's farm,  $1\frac{1}{2}$  miles west of the Rynd farm, there may be seen one of these vertical fissures in the strata above water free, where a man may walk under ground for the distance of 170 feet and look up 100 feet high. Similar openings may be seen near the Pit Hole, one of the tributary streams of the Alleghany river. They seldom contain oil in quantity. I therefore infer that they are lines of elevation, and the oil in the rock flows from them.

The lowest members of the Oil Bearing Strata commence in the vicinity of the town of Waterford, in Erie County, Pennsylvania, and incline gently in a southerly direction to the town of Union, where they disappear beneath the range of hills south of that village. About 8 miles to the south of this, we find Chestnut Ridge, where the Oil Bearing Strata are complete, but incline at an angle of 10 degrees to

the south to Hidetown, so that the majority of the oil flows in the direction of Oil Creek. There is a sinclinal trough in the strata beneath the town of Titusville and an anticlinal roll crossing at the lower dam near the Stackpole farm, and from this point there are a series of small undulations and crimps in the strata all the way to the mouth of Oil Creek. The stream running step-like denuding its passage nearer and nearer to the great oil pool below, where a depth of 530 feet from the surface produce flowing wells for a distance of 7 miles near to the mouth of Oil Creek.

The out-croppings of the lowest members of the Oil Bearing Strata are quarried at points along the line of the "Philadelphia and Erie Railroad," in Erie County, Pennsylvania, and the stones taken out are used for building purposes. The foundation walls of Mr. Riley's Hotel in the town of Union was built altogether of stone from one of these quarries, and the petroleum oozes out, staining the face of the walls to a great extent.

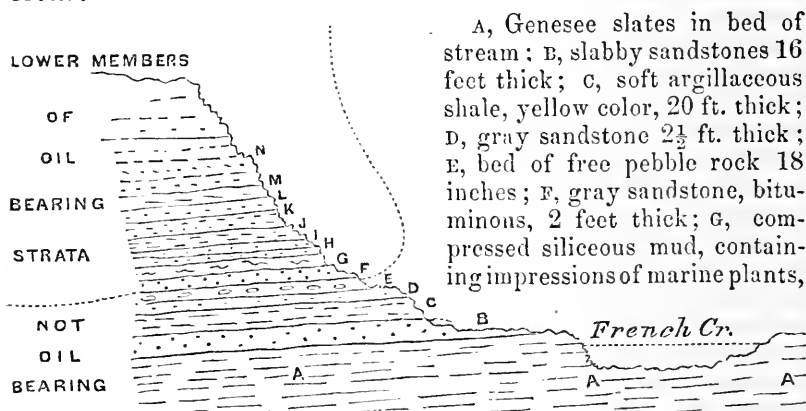
The Academy in Waterford, Erie County, Pennsylvania, was built 41 years ago with stones quarried on Big French Creek from fourth sand rock (so called); the petroleum still oozes out from the walls and trickles down the front and sides of the building, disfiguring its front so much up to the present day that the Academy commissioners resort to painting to conceal the petroleum stains. The north side of the building which I examined closely with a magnifying glass (to ascertain if I could discover any marks or impressions of fossil remains to produce oil in the rock) is very much disfigured, and portions of it so much so that it has the surface appearance of an old oily iron pot.

Such facts as the foregoing led me to a course of reasoning that the oil must exist in the rock, and the cause of its being there must have arisen from a buried vegetable growth which took place prior to the so-called carboniferous clay. For the petroleum to have flowed from the coal fields up hill in a northerly direction against the inclination of the strata, and found to exist in these particular beds of sandstone and shale, and not in the overlaying rocks, is an impossibility. And for the oil to have flowed from the true carboniferous deposite, before its elevation or subsidence of the waters, to points where the towns of Union and Waterford now stand, is poor reasoning, for the oil would have raised to the surface of the waters before running so far to settle in the Devonian Formation far below the carboniferous strata.

Knowing that the lowest coal beds of our coal fields are generally found to be the thickest, and were produced from a rank growth of vegetation, I supposed that there may have been a great mass of marine plants washed into the trough of the Devonian Sea immediately above the Genesee slate far below the valley of Oil Creek at the time the sand was laid down to form sand rock, and by their decomposition produced the rock oil; hence I kept a steady eye on each layer of rock as it presented itself to me in exposed places in hopes that the Stony Book of God, whose pages might be the true authorities in the case, should reveal to me in a suit of fossils the true cause of rock oil so deep

and so far from the coal fields. And I am pleased to state that the result of my investigations has far exceeded my anticipations, by the discovery of a great profusion of impressions of marine plants of the fucoid family in micaceous slabby sandstones along the edge of the base of the hills from the Stackpole farm  $2\frac{1}{2}$  miles below Titusville to the mouth of Cherry Tree Run. This encouraged me to make a thorough examination of the out-croppings of the Oil Bearing Formation. I proceeded at once to Big French and Le Bocuff Creeks in Erie County, where I found above the Genesee slates a bed of siliceous mud filled with impressions of marine plants and possessing a strong bituminous odor.

The following diagram is a geological column taken on the spot, September, 1861, about 5 miles from the town of Union on Big French Creek :



highly bituminous, 2 feet thick ; H, micaceous sandstone, bituminous, 1 foot ; I, hard sandstone, bituminous, 10 inches ; J, soft olive-colored shale, bituminous, 2 feet ; K, soft slabby sandstone, bituminous, 6 ft. ; L, hard sandstone, embracing irregular seams of quartz pebbles, bituminous, 4 feet ; M, argillaceous shale, light color, bituminous, 2 ft. ; N, gray sandstone, containing thin bands of hard sandstone, bituminous, 45 feet thick.

On examining the slopes of the hills in this vicinity I saw petroleum oozing out from their sides above the bed of free pebble rock, E ; but below this stratum there was not the least indication of petroleum issuing from their slopes, and no bituminous odor arising from any of the rocks below this point when struck with a hammer. Now, if one could follow the bed of siliceous mud, G, to its deep pool below the valley of Oil Creek, he no doubt would behold a sheet of oil, the result of fermentation of a large mass of marine plants that at one time grew upon the floor of the Devonian Sea, many of which may have been washed into this sinclinal trough by currents of salt water or by its oscillatory motion, for ripple washings may be distinctly seen upon the Oil Creek flags.



The plants which produced the oil in the rock existed and flourished at a long period of time before the vegetation which now forms coal beds; they are unlike the vegetable impressions found in the accompanying shales and clays associated with beds of coal, and grew when the flagstones and shales of Oil Creek were laid down by salt water currents, the sand rock then being sand and the shale mud, which caught and filled away in the secret chambers of the deep every new vegetable growth from the pebble rock, E, beneath the oil pool up to the top of the Oil Bearing Strata.

The climate was so hot during this age of marine vegetation, and the growth of plants so rapid and rank, caused by the supposed large amount of carbonic acid gas and hydrogen then composing the atmosphere, that these conditions on the face of the earth produced plants containing less carbon and more hydrogen than the plants which produced coal beds, hence the fermentation produced oil, now petroleum. Had these marine plants taken up more carbon and less hydrogen than by fermentation they would have produced seams of coal. The discovery by me of a thin seam of bituminous coal in the upper members of this Oil Bearing Formation aids to substantiate the theory advanced, for the ancient marine vegetation which produced the petroleum in the Devonian Formation, gradually passed into a more carboniferous one.

Petroleum found in bituminous coal basins no doubt originates from beds of coal. Rock Oil found in other districts of North America may be derived from the decomposition of animal tissue, but it is my opinion that the petroleum of Oil Creek Valley, Pennsylvania, is the result of the decomposition of marine plants. Oils derived from animal origin have an offensive odor, whereas the oils from vegetable matter has a more pleasant odor. If their chemical compositions should be similar, their physical characteristics are entirely different. Oil found in bituminous coal fields is of a brown color, whereas the oil found in Oil Creek Valley is of a greenish hue. The substance iodine at the present day is found to exist in sea plants, but it may not have existed in the marine plants that produced the oil of Oil Creek.

The oil of Oil Creek is the result of fermentation of vegetable matter of long standing, and the carburetted hydrogen gas evolved was "cabined, cribbed, confined" for a long period of time until the boring tools probed it to the great pool below, then this gas became the chief agent in bringing the oil to the surface, producing spouting wells whose yield has been from 200 to 2000 barrels of petroleum each per day.

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*Water-Proof Walks.*

From the London Mechanics' Magazine, December, 1862.

But a new method of path-making is fast coming into vogue, and will soon be universally adopted for its cheapness, general excellence,

and permanence; in fact, when once well done, it lasts for ever. Instead of making the walk of loose material, on the old fashion, concreting is resorted to, by which the appearance of gravel is retained with all its freshness and beauty of contrast to grass and flowers, and the walk itself is rendered as dry and durable as the best pavement. The *modus operandi* is as follows:—Procure a sufficient quantity of the best Portland cement, then with the help of a laborer turn up the path with a pick, and have all the old gravel screened, so as to separate the loam and surface weeds from it, and to every six parts of the gravel add three parts of gritty sand of any kind—but soft pit sand is unsuitable—and one part by measure of Portland cement. When these are well mixed together in a dry state, add sufficient water to make the whole into a moderately stiff working consistence, and lay it down quickly two inches thick on a hard bottom. A common spade is the best tool with which to spread it; it must be at once spread, as it is to remain for ever, and a slight convexity given to the surface. In 48 hours it becomes as hard as a rock; not a drop of rain will go through it, and if a drop lodges on it, blame yourself for not having made the surface even; but a moderate fall is sufficient with such an impenetrable material. Not a weed will ever grow on a path so formed; not a worm will ever work through it; a birch broom will keep the surface clean and bright, and of course it never requires rolling. It is necessary to be very particular as to the quality of the cement, for a great deal of rubbish is sold under the name of real Portland. For the flooring of a green house, fowl-house, potting-shed, or barn, this is the best and cheapest that can be had—always clean, hard, and dry, and never requiring repairs of any kind if carefully put down in the first instance.—*Gardener's Weekly Magazine and Floricultural Cabinet.*

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### *The First English Steamer.*

From the Lond. Mechanics' Magazine, December, 1862.

The *Margery* was built at Dumbarton, by the late Mr. W. Denny (father of the eminent firm of shipbuilders of that name, now also in Dumbarton), for W. Anderson, merchant, Glasgow, and when launched was christened the *Margery*, after his eldest daughter, who named her, and who is still alive, and at present a resident in London. At the close of 1814, Captain Curtis was sent by a London company to Glasgow, to negotiate with Mr. Anderson for the purchase of the *Margery*, which was effected, the only stipulation made by Mr. Anderson being that the name of the steamer should at no future time be changed; this Captain Curtis agreed to, and the promise was faithfully kept. Captain Curtis took the *Margery* through the Forth and Clyde Canal, and invited a large party of Mr. Anderson's friends to accompany him while passing through the canal, and was most hospitable in his

entertainment to them. There remain but two of this party now alive, viz: the lady after whom the steamer was named, and a clergyman, a friend of Mr. Anderson's. The writer of the article in the *Dumbarton Herald* is quite correct as to his statements of the fear and wonder which the appearance of the *Margery* excited on the coast, while on her passage to England, as well as among the English fleet; in most cases she was supposed to be a vessel on fire. The *Margery* was the first steamship that ever sailed in English waters, and made her first trip to Milton, below Gravesend, on the 23d January, 1815. She was ultimately taken to Paris, where not many years ago her timbers were still lying on the banks of the Seine. Mr. Anderson was, therefore, owner of the first steamer that was ever seen in London, and also in Paris; he also owned the first that ever crossed from Scotland to Ireland (viz: the *Greenock*, built soon after the *Margery*), which he took to Belfast; he also took the first to Londonderry—the *Princess Charlotte*. The late Mr. Anderson was grandfather to the Messrs. Gwynne, engineers, of Essex Street Wharves, whose large centrifugal pumping engine in the International Exhibition attracted so much admiration and attention during the past season.

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For the Journal of the Franklin Institute.

### On a National Academy of Science and Technological Institutions.

By JOHN W. NYSTROM, C. E.

It is very gratifying to know that Congress at its last session passed a bill to establish a *National Academy of Science*, which will no doubt be of great value to the country for the cultivation of the natural resources of our mind and for the improvement of our moral dignity and standing among nations in a political view, but at the same time, —considering the peculiar circumstances in which the country is now placed,—prosperity is of greater importance, and the former cannot be maintained without the latter. I am well convinced that we are behind some other nations in science, but am positively assured that we have more science in the country than we can properly manage; it is the *application of science to practice* which requires immediate attention and special institution.

In Europe they have institutions for the combined science and practice, the want of which is most severely felt in this country and for which we suffer most extremely. A *National Technological Institute*, with workshops and laboratories connected with Navy Yards and private establishments, are of more importance in this country than in Europe, for the reason that mechanical skill and inventive ingenuity are here more developed, and the want of applied science wastes away a proportionate quantity of time and money.

I may be mistaken, but am under the impression, that in the pre-

sent condition of our political system, an Academy of Science would not now answer the expected purpose, as it will a few years hence; while a Technological Institute would enable us to rise gradually and surely to the position due to us among nations, and when once so raised we would never fall.

I have adopted this country as my own, and care for its prosperity as much as any American that ever lived; my attempt to correct what I consider is wrong is in pure respect to you who came here a few days before me.

We have plenty of scientific books in the country, mostly written by Professors in Colleges, who have very little chance to apply their knowledge to practice, and are therefore destitute of practical examples. We oftentimes find most valuable formulas given by scientific men in such a shape that it requires to know as much or more than the author to employ them; they are not only not trained to a practical shape, but the meaning of letters are rarely explained in a technical language. It is surprising to see how excellently mathematicians have succeeded in keeping the simple science of the Calculus in such a perfect mystery; it reaches very few among us, not for the difficulty of learning it, but simply for the want of its application to practice. We find books on the Calculus of several hundred pages, and not a single practical example, which makes the science very difficult and tedious to learn, and when acquired, very rarely further developed, but stored away in the head so that it cannot be found when wanted.

We find simple formulas occupying several pages in explanation, which by a simple example applied to practice would by a few lines print it in the student so that he would never forget it. *A National Technological Institute* of high order would effectually remove such deficiencies.

Up to the present day the knowledge of steam-engineering is far behind our knowledge of science, for which the country suffers extremely. Our marine engines and boilers are not only unnecessarily complicated, but most extravagant in the consumption of fuel; our locomotive engineers ought to be ashamed of themselves when they come with their thunder-storm blowing out smoke and fire to suffocate passengers and set fire to houses and forests, which evil could be so advantageously employed to the general interest. My statements are not based on mere supposition, but on knowledge and experience; I know what I have seen, what I have done, and what you are doing, and will point out the evil if called for, but here is not the place to describe it.

Only a few years ago there was not a single propeller steamer in the United States with properly constructed air-pumps and foot-valves, for the want of knowledge of the physical laws by which it operates; errors of the same kind were committed in England and other countries. Propeller steamers designed to go to Europe succeeded some of them to make one passage, and some broke down at but a short

distance from the American shore and returned; most of those steamers existed but a short time. I will give names and describe the cases if necessary,—the U. S. Steamer *San Jacinto* was one of the number. When I saw the evil I worked out practical formulas and published the physical laws by which it operates, after which the errors in the air-pumps and foot-valves were corrected. I believe myself to be the first one who has worked out that theory when there was no publication of that kind in the whole world.

Had the subject of the expansion and other properties of steam been understood by the engineers in the Navy, it would have saved the Erie expansion experiments, and our men-of-war lately built would have given better satisfaction. I was the first one to prove the folly of the Erie expansion experiment, and published an article on the same in the *Scientific American* in January, 1861, but omitted to explain what deceived Mr. Isherwood in the experiments made on the stationary engine in New York. There is yet no publication so complete with practical formulas and tables of the expansion of steam, its economy and application to different kinds of engines, as that of my Pocket Book, which has been partly copied in Europe.

The knowledge of steamship performance has until lately been on a very low point. Steamship contractors have often bound themselves to accomplish more than established by physical laws, and the Navy Department has bound contractors with impossibilities for the want of proper knowledge of steamship performance. A few years ago an engineer imposed on the public some exaggerated statements of steamship performance, which I attempted to correct, but was overwhelmed with mystical proofs in aid of the exaggerations; a short time after the performance the steamer in question turned out a failure and disgrace to the country. There is yet no publication with so reliable data of steamship performance as that in my Pocket Book. I could point out thousands of cases where blunders were made in practice for the want of appreciation of, and disrespect to the science in our possession, but am afraid to be misunderstood, although I am well convinced that for the general interest many will consider it their agreeable duty to give my views a liberal consideration.

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Translated for the Journal of the Franklin Institute.

*On some New Properties of Sulphur.* By M. DIETZENBACHER.

*Note Presented to the Academy of Sciences of Paris.*

By M. H. SAINTE-CLAIRE DEVILLE.

A small quantity of iodine, bromine, or fluorine modifies the physical and chemical properties of sulphur in a very remarkable way. The sulphur becomes soft, malleable at ordinary temperatures, and retains these properties for a considerable time. It is, moreover, partly or entirely transformed into that curious modification of sulphur discovered by *M. Charles Sainte-Claire Deville*, and called by him *insoluble sulphur*.

1st. By heating to about  $180^{\circ}$  ( $356^{\circ}$  Fahr.) a mixture of 400 parts of sulphur with one of iodine, there is procured on cooling a sulphur which remains for a long time elastic. It may be obtained in flexible sheets by casting the sulphur upon a glass or porcelain plate.

This property shows itself with even a much smaller proportion of iodine. The iodide of potassium acts in the same way as iodine. The sulphur thus treated becomes insoluble in the sulphuret of carbon. The liquid assumes a violet color.

2d. The action of bromine on sulphur is analogous to that of iodine, only that in place of a sulphur with a black color and metallic lustre, there is obtained a sulphur of a wax-yellow color much softer than the other: this state is lasting. One per cent. of bromine and a temperature of  $200^{\circ}$  ( $392^{\circ}$  Fahr.) will give this modification. This sulphur contains from 75 to 80 per cent. of sulphur insoluble in sulphuret of carbon.

3d. By passing a current of chlorine through sulphur brought to a temperature of  $240^{\circ}$  ( $464^{\circ}$  Fahr.), there is obtained a kind of sulphur which is easily drawn out in threads, and the pieces of which can be kneaded together.

With sulphuret of carbon it behaves in the same way as the sulphur treated with bromine. But when freshly prepared it yields 10 per cent. more to the liquid. After being kneaded for an hour or two this sulphur suddenly hardens, and becomes completely insoluble in sulphuret of carbon.

These facts may serve to explain certain details of the manufacture of vulcanized india-rubber by means of sulphur and its chloride. Some of them confirm results before obtained by M. Beolthelet.

*Comptes Rendus*, 5th Jan. 1863.

For the Journal of the Franklin Institute.

### *The Propeller Nippon.*

Hull built and vessel owned by Capt. R. B. Forbes, Boston, Mass. Machinery constructed by Atlantic Works, Boston. Route of service, Coasts of China and Japan.

*Hull*.—Length between perpendiculars, 154 ft. Do. over all, 157 ft. 6 ins. Breadth of beam, (extreme), 25 ft. 6 ins. Depth of hold, 9 ft. 6 ins. Do. to spar-deck, 16 ft. Draft of water, (light),—forward, 7 ft.—aft, 10 ft. Do. (loaded), forward, 8 ft. 6 ins.—aft, 11 ft. 6 ins. Rig, Barkentine. Tonnage, 475 tons.

*Engines*.—Vertical direct. Diameter of cylinders, 26 ins. Length of stroke of piston, 2 ft. 2 ins. Length of propeller shaft, 32 ft. Diameter of do., 8 ins.

*Boilers*.—One—return flue. Length, 25 ft. Diameter of shell, 10 ft. Fire surface, 1600 sq. ft. Grate surface, 64 sq. ft. Coal consumed per day, 13 tons. Is fitted with a blower.

*Propeller*.—Diameter, 9 ft. Blades, 4. Material, iron.

*Remarks*.—The ends of this vessel are long and sharp, with slightly concave lines; the stem is nearly upright and handsomely curved in

the wake of the forefoot, and her stern is semi-elliptical and well proportioned. Viewed broadside on she presents a lively sheer graduated her whole length, and as great care has been bestowed in the regularity of her planking, she looks finely. She has 10 inches dead rise at half-floor, and to strengthen her bilges, and aid her in holding on by the wind, and prevent her from rolling when going free, she has bilge-strakes 60 feet long which extend outside of the planking  $6\frac{1}{2}$  inches, in all ten inches thick, and these are tapered toward the end to blend with the hull.

Her partner beams are 15 feet by 10, boiler-hatch beams, 10 feet by 7, and all others in the lower deck frame are 7 feet by 7—they are 3 feet apart—of haemetac. The deck is of white pine, 3 inches thick. The upper deck frame is of haemetac; the hatch-beams, mast-beams, and forecastle-beams are 8 inches by  $4\frac{1}{2}$ , the balance 5 inches by  $4\frac{1}{2}$ , and 2 feet apart. The deck is of white pine,  $2\frac{1}{2}$  inches thick. The lower deck water-way is 12 inches by 10, ceiling in between-decks  $1\frac{3}{4}$  inches, spirketing 6 inches high, and planksheer  $4\frac{1}{2}$  inches—of pine; the top of the planksheer is 17 or 18 inches above deck. The top timbers are 8 inches by 5, tapering to 8 inches by  $4\frac{1}{2}$ , and 8 inches apart; of haemetac. The outer plankings or bulwarks, from the planksheer to the upper deck, are of 2-inch pine, excepting on the round of the stern and on the bow, where they are of oak. The stem, sided, 12 inches, and stern posts, 13 inches, are of oak, also the knightheads; the keel of rock maple, one length, and two of white oak,  $12\frac{1}{2}$  inches and 12, with lock scarphs 10 feet and 3 inches shoe.

The frame or ribs of this vessel are of Pembroke angle iron,  $3\frac{1}{2}$  inches by  $2\frac{1}{2}$ , and  $\frac{1}{2}$ -inch thick, extending all in one piece from the keel to gunwale; they are but 16 inches from centre to centre. The cross floors consist of reversed angle iron, and  $\frac{5}{8}$ -inch thick plate in wake of engine and boiler, on every frame, and elsewhere plate with angle iron on every alternate frame. There is a water-tight iron bulkhead,  $\frac{1}{4}$ -inch thick, stiffened by nine vertical angle irons at the mainmast, to which the boiler and coal bunkers of iron extend; another similar bulkhead about 16 feet from the stem, and also one abaft the engines, 10 or 12 feet forward of stern post, thus dividing the vessel into four water-tight compartments. The main keelson, riveted to every floor, consists of two angle irons, 3 feet by 3 feet 6 inches, and running through the main bulkhead to the engine floors, which are four feet high above the keel. Instead of ceiling, there is a system of bracings of 3 inches by  $\frac{5}{8}$ ths bar iron, crossing each other diagonally, and about three feet apart. This strapping, or diagonal bracing, is securely fastened to a heavy stringer plate, 6 inches wide by  $\frac{3}{4}$  thick, running fore and aft at the lower part of the plate iron knees, which are attached to the beams by screw bolts and nuts; the lower ends of the strapping are firmly riveted to a bar keelson,  $4\frac{1}{2}$  by  $\frac{5}{8}$  inches, attached to the cross floor heads by double rivets. The planking of the vessel is of the best white oak; the garboard strake 5 inches thick, bolted edgewise to the keel at the distance of four feet, the second

strake is 4 inches, and all the rest to planksheer  $3\frac{1}{2}$  inches. This planking is fastened to the angle iron ribs, by galvanized iron bolts with round heads, having a square shoulder  $\frac{3}{4}$  of an inch from the head toward the screw ends; these bolts are driven from the outside through the ribs, and finally set up by galvanized nuts on the inside of the angle iron ribs. Between the oak plank and the frames there are strips of tarred felt, and elsewhere wherever oak and iron came in contact.

The rig of this vessel is peculiar, and may be called a "barkentine;" but it differs from the usual rig so-called, inasmuch as the square sails are on the mainmast, the fore and mizzen being fore-and-aft rig with boom sails and gaff topsails; the fore stay-sail or main jib sets on a stay setting up to the knightheads; the bowsprit is really nothing more than a jibboom, on which sets a sail, the stay of which goes to the masthead close up to the fore cap, and to the topmast there sets a jib topsail.

The dimensions of the spars, &c., are as follows: Foremast above deck, 60 feet; head, 10 feet; diameter, 19 inches; rake, 1 inch to the foot; distance from outer part of stem, 34 feet; topmast, 42 feet; pole, 8 feet; foreboom, 41 feet; gaff, 29 feet. Mainmast, 45 feet from the foremast; 51 feet 6 inches above deck; rake, 1 inch to the foot; head, 12 feet 6 inches; diameter, 20 inches; topmast, 25 feet 6 ins.; topgallant, 15 feet; royal, 11 feet, and pole, 5 feet; total, 56 feet 6 inches, all in one stick. Main yard, 52 feet; topsail yard, 39 feet; topgallant, 29 feet; royal, 20 feet 6 inches. On this mast there is no square mainsail, only a small storm spencer, fitted to brail to the mast. The mizzen is 45 feet 6 inches from the mainmast, and is 60 feet above deck, with 8 feet head, and a topmast on which is set a flying gaff topsail and a stay-sail. The topmast is 32 feet; mizzen boom, 41 feet; gaff, 23 feet. As the smoke pipe comes up in the centre of the space between the main and mizzenmasts; this is the only way by which sufficient canvass can be safely carried on the mainmast. The rig is certainly novel and unique, and will doubtless propel as well and work as well as the regular barkentine.

As the fastenings of the bottom plank are of galvanized iron, countersunk three-fourths of an inch, and well plugged, when the bottom is well covered by felt laid on "half stuff," the composition will wear as well as on a purely wooden ship and insure a clean bottom.

The advantages of the mode of building as adopted in the *Nippon*, are a good combination of lightness and strength, greater durability, especially in hot climates, than if the vessel was built wholly of wood, greater carrying capacity, better ventilation, and consequently more healthy than a wooden ship; ability to get at a leak, large or small, from the inside, when not full of cargo; no stowage for vermin; easily repaired. She has two important advantages over iron vessels; first, the absence of condensed vapor, which always takes place in iron vessels, making them cold in cold weather, and hot in warm weather; and secondly, the bottom being coppered will keep clean better. In short, there can be no doubt of the superiority of this



mode of building over wood, and of its being, taking all things into consideration, as good as all iron. For light draft war-vessels, it is very superior to all wood, as the amount of weight saved will enable them to be plated in the wake of machinery sufficiently thick to keep out many of the lesser projectiles.

In regard to the mode of constructing vessels by a combination of wood and iron, as adopted by Capt. Forbes in this instance, though not identical, it is on the same general principle as that used and patented by Capt. R. F. Loper, of Philadelphia, some fourteen years since.

B.

For the Journal of the Franklin Institute.

*Particulars of the Barque Tycoon.*

Hull built and vessel owned by Charles Mallory, Mystic, Conn.

**HULL**—Length between perpendiculars, 152 ft. Do. over all, 172 ft. Breadth of beam, 35 ft. Depth of hold, 16 ft. 8 ins. Frame of white oak and chestnut; planked with oak and yellow pine; oak bottom; yellow pine ceiling; securely fastened with copper. Tonnage 850 tons.

**MASTS, YARDS, &c.**—Foremast—whole length, 61 ft.; size, 24 ins.; head, 12 ft. Mainmast—whole length, 63 ft.; size, 25 ins.; head, 12 ft. Mizzenmast—whole length, 61 ft.; size, 18 ins.; head, 9 ft. Fore and main topmasts, 35 ft.; size, 13 ins.; head, 6½ ft. Mizzen topmasts, 30 ft.; size, 11 ins. Mizzen topgallantmast, 12 ft.; pole, 6 ft. Fore and main topgallantmast, 22 ft.; size, 9 ins. Fore and main royal mast, 12 ft.; pole, 6 ft. Fore and main yards, whole length, 60 ft.; size, 15 ins.; arms, 3 ft. Upper topsail yards, whole length, 48 ft.; size, 11½ ins.; arms, 2½ ft. Lower topsail yards, whole length, 52 ft.; size, 12½ ins.; arms, 1 ft. Topgallant yards, whole length, 36 ft.; size, 8 ins.; arms, 1 ft. Royal yards, whole length, 29 ft.; size, 6 ins.; arms, 1 ft. Gaff, whole length, 30 ft.; size, 6½ ins.; end, 4 ft. Spanker boom, whole length, 37 ft.; size, 8 ins.; end, 2 ft. Jib boom, 15 ft.; size, 13 ins. Bowsprit, outboard, 10 ft.

B.

For the Journal of the Franklin Institute.

*Particulars of the Side-wheel Steamer C. W. Thomas.*

Hull built by Mr. Rufus W. Cushman. Machinery constructed by Mr. R. S. De Mott. Commander, Captain A. W. Davidson. Owners, Messrs. McKay & Aldus.

**HULL**—Length on deck, 137 ft.; breadth (inside of guards), 22 ft. 7 ins.; do. (outside), 36 ft. Depth of hold, 8 ft. 4 ins. Draft of water at load line, 4 ft. 6 ins. Tonnage, 254 tons.

**ENGINES**—Vertical beam. Diameter of cylinder, 28 ins. Length of stroke of piston, 7 ft. 6 ins.

**BOILERS**—Return tubular. Uses a blower.

**WATER-WHEELS**—Diameter, 21 ft. 6 ins.; face of do., 4 ft. 6 ins.

**Remarks**.—As this is the first side-wheel steamer built in a private yard in Boston, a description of her will not be uninteresting. This vessel has very concave lines forward, a long sharp bow, and a rounded stern. Her frame, ceiling, and planking are of seasoned white

oak, square fastened throughout, and through tree-nailed with locust, and screw-bolted in her heaviest planking and clamps. The keel is of rock maple, 12 inches square; the floor timbers 5 by 9 inches, and her keelsons—of which she has five—are from 12 inches square to 10 by 12, all bolted through and through. Her clamps and bilge strakes are 4 by 14 inches; the clamps are set up with screw bolts. The garboards are also 4 inches thick, and the rest of the planking and ceiling are  $2\frac{1}{2}$  inches, all of oak. The beams amidships are 10 by 12 inches, diminishing by regular gradation toward the ends. It will thus be seen that this vessel is strongly built.

The *C. W. Thomas* has two decks. Under the first is her dining saloon forward of the boilers, with store-rooms, and other apartments, and aft several state-rooms, &c. On this deck she has a saloon which is a gem of neatness—spacious, well lighted and ventilated, and gorgeously furnished. On the second deck are several spacious state-rooms, designed to be occupied by her captain and officers.

This vessel was designed and modeled by Mr. Nathaniel McKay, brother of the well known naval architect, Donald McKay, of Boston.

Upon the trial trip of this steamer, everything worked satisfactorily, and her performance demonstrated to all then with her that she was a success.

B.

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## FRANKLIN INSTITUTE.

### *Proceedings of the Stated Monthly Meeting, March 18, 1863.*

John Agnew, Vice President, in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, the Royal Society, the Institution of Civil Engineers, and the Society of Arts, London; l'Ecole des Mines, Paris, et la Société Industrielle de Mulhouse, France; Der Nieder-Oesterreichischen Gewerbe-Vereines, Wien, Austria, Dr. E. M. Dingler, Angsburg, Germany; the Canadian Institute, Toronto, and Major L. A. Huguet-Latour, Montreal, Canada; Hon. John Cradlebaugh, Lieut. Col. C. C. Tevis, and Charles Colné, Esq., Washington, D. C.; the Board of Water Commissioners, Detroit, Michigan; the New York State Lunatic Asylum, Utica, Prof. James Hall, Albany, the Chamber of Commerce of the State of New York, and Capt. E. B. Hunt, New York; T. C. Zulich, Harrisburgh, Prof. John F. Frazer, Prof. John C. Cresson, Isaac S. Cassin, Esq., and the Pennsylvania Institution for the Blind, Philadelphia, Pennsylvania.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of February was read.

The Board of Managers and Standing Committees reported their minutes.

The Actuary reported that the following Standing Committees have organized by electing their Chairman, and appointing their times for meeting, viz :

<i>Committee.</i>	<i>Chairman.</i>	<i>Time of Meeting.</i>
On Models,	James Agnew,	1st Monday evening.
“ Library,	John Ferguson,	1st Tuesday “
“ Exhibitions,	John E. Addicks,	1st Friday “

Candidates for membership in the Institute (5) were proposed, and the candidates proposed at the last meeting (9) were duly elected.

Mr. Howson exhibited diagrams and models of A. B. Cooley's apparatus for obstructing rivers, consisting of a series of blocks or frames chained together, and anchored at each end of the series to one of the sides or shores of the river. Each block resembles a tetrahedron in shape (the points being tipped with iron or steel), so that upon whatever side the block may lie, a sharp apex will be presented, which should be about five feet below the surface of the stream. The blocks are at such a distance apart that no war vessel of formidable size can pass through the channel without coming in contact with one or other of the frames. When no longer required to obstruct the channel, the blocks may be disconnected and separately removed.

Mr. Howson also exhibited several breech-loading fire-arms. The first is the invention of L. H. Gibbs, and manufactured by W. F. Brooks, of New York. In this arm the trigger guard is used as a lever, on depressing which the barrel is thrown forward, and tilted up at the rear, so as to expose the breech ready to receive a load. Another arm, the invention of B. F. Joslyn, of Connecticut, is closed at the breech by a cap hinged to the side and rear of the barrel, and is so constructed as to automatically discharge the empty cartridge case from the gun, on unclosing the breech.

H. Liebert's substitute for gunpowder was exhibited. Its principal ingredients are prussiate of potash and cyanide or ferro-cyanide of potassium. A powder composed of these two substances, in combination with nitrate of soda, charcoal, sulphur, and other ingredients, any or all of which may be employed, can be compounded without that danger of explosion which is incurred in making the ordinary substitutes for gunpowder, in which chlorate of potash is generally used.

Mr. J. N. Pierce, of Darby, Delaware Co., Pa., exhibited numerous specimens of artificial slate, for the use of schools, colleges, &c. On painting any suitable surface with a preparation, patented by Mr. P., a slate-colored ground will be formed which answers equally as well as slate for drafting or marking purposes. Paper, linen, or any textile fabric may be used to form convenient portable slates, which can be rolled or folded up for transportation.

Mr. P. also exhibited pencils made of talc.

Mr. E. Brady exhibited his Patent Mode of Attaching Armor to Vessels.

Mr. Washinton Jones exhibited specimens of gunpowder similar to that which exploded at Wilmington, Delaware, a few days since.

Mr. Nystrom exhibited some tools and instruments, namely, a Lathe, Square, Compasses, Callipers, Telescope, Dioptric Rule, Hand Vices, Stocks and Dies, Inkstand, Pentograph, Drillstock, &c., about twenty-five pieces, and made the following remarks:—I have brought to the meeting this evening some tools and instruments made by myself while a student of the Royal Technological Institute, Stockholm. I have not brought them here to show you something new in design or workmanship; they are, I believe, most of them familiar to you; but my object is to call your attention to how men are brought up and how Technological Institutions are arranged in Europe. The U. S. Congress has passed a bill to establish a National Academy of Science, about which I have written an article for the *Journal*, which will appear in the next (April) number. In that article I endeavor to show the necessity of a National Technological Institute of high order in preference to an Academy of Science.

The Royal Technological Institute, Stockholm, where I have made these instruments, have drawing room, machine shop, pattern shop, blacksmith, tinsmith, and chemical laboratory connected with it, where the students work between lecture hours. It is not expected, neither is it necessary, that the student shall become an accomplished mechanic, but the object is to turn his mind on the work about which he is studying and calculating; when confined to only books and blackboards his imagination very rarely extends any further; he acquires the knowledge mechanically, as it were,—the study becomes tedious to him, and when brought to bear on practice the most simple problem may confuse him. When the student is brought up in the combined theory and practice, he acquires taste for work, good workmanship, and proper proportions, and the application of his science becomes a pleasure to him; he studies mathematics at the same time he learns to draw, physics and mechanics at the same time he makes his tools and models for machinery; his science is applied as fast as he acquires it, and he will never forget it. I made a great many models at the institute, and you will see my tools are pretty well worn. When I studied optics, I made optical instruments, of which I have brought two here, one a telescope and the other a dioptric rule. The rule may be something new to you, and I will explain its operation. On the one end, as you see, is mounted a round glass; the plan of which is at right angles to the rule; half the glass is transparent and the other half a looking-glass; when placed in position on the board I look through the glass so that I see the pupil of my eye in the centre of the looking-glass and at the same time look through the transparent part on the object; when the rule is properly adjusted the line is drawn on the board. When I studied acoustics, I made musical instruments, the drawings of which are in this book, containing nearly 200 drawings of machinery which I made at the Institute.

Another instrument which may be new to you is a scriber, by which

to scribe concentric circles around a hole without knowing its centre; as you see, there is a cone on the one leg which is placed in the hole, while the other leg scribes the circle. I wish to be distinctly understood, that I have not brought these tools to the meeting to show what I can do or how smart I am, but simply to impress upon you the necessity and importance of a Technological Institute in this country.

There are also institutions in Sweden in connexion with private establishments, where the student finishes his practical training. I finished mine under Captain Carlsund Motala. When a student is so brought up, he is able to make himself useful and bring his science to bear on the general interest.

America has taken the lead of the world in popular education; its institutions are copied into Europe; but it remains to follow up and take the lead in the nobler and purer refinement of our nature. We have the best materials on the globe by which to accomplish that object; the question is only time and what course to be taken. There is now a very distinct line drawn between practical and scientific men; the more we cultivate the branches separately the more distinct will the line be, the less will we understand one another, and without the aid of Technological Institutions we may ultimately fall to the low grade of our present politicians, to make speeches against one another and call one another by nicknames. A chain cannot hang together if one link is wanted, and it is the wanted link which I am endeavoring to repair.

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## BIBLIOGRAPHICAL NOTICES.

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*Report on the Geology and Agriculture of the State of Mississippi.*

By EUGENE W. HILGARD, Ph. D., State Geologist. Printed by order of the Legislature. E. BARKSDALE, Jackson, Miss., 1860.

A plain practical exposition of the scientific and practical results of a survey made for the purpose of developing the mineral and agricultural resources of the State of Mississippi. The author in his preface has thought it necessary to defend his scientific language and scientific detail, but it is to be hoped, that the painful circumstances which have occurred since the book was written will give him a more extended audience and one before whom no such defence is needed. On the other hand, were we disposed to find fault, it would be by admonishing him that the duty of a writer on a scientific subject is twofold—first, to make his subject as easy of comprehension and as pleasant to peruse as his talents and the nature of the subject will permit; but always remembering, in the second place, that scientific precision must not be sacrificed to popularity, and that his duty is not only to gratify but also to correct and raise the public taste. We would not in a popular treatise speak of water as the *protoxide of hydrogen*, nor complain of a popular bivalve being called oyster in place of a more latinic name;

but we do object to the calling our tulip tree a poplar, which Mr. Hilgard knows and admits that it is not; as we protest against the vulgarity of naming our magnificent Buttonwood tree after the commonplace European Sycamore. (Do not let it be implied that this error occurs in Mr. Hilgard's report.)

The report contains a great deal of information interesting partly to the scientific, partly to the practical man. The resources of the State, while they want the richness of some of the middle regions of our Union, are valuable and well worthy of the development which we hope will follow the present political convulsions. F.

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*Union Foundations a Study of American Nationality as a fact of Science.* By Capt. E. B. HUNT, Corps of Engineers, U. S. A. New York, Van Nostrand, 1863, 8 vo. pp. 61.

The gist of this pamphlet is an argument drawn from the physical geography and statistics of our country, that its separation into fragments is a moral if not physical impossibility, or that, in other words, the cost and inconveniences of a separation are indefinitely greater than those of any war for the maintenance of unity. The data of the argument are excellently stated and clearly developed, and if any one needs an argument on this point they could not wish a better than is here given. But it never has seemed to us that this was the true question. With the exception of a few fanatics on each side, we believe the whole people of the United States are convinced of the necessity and determined in favor of union. The true and only question is under whose authority? under what constitution? Mr. Jefferson Davis or Mr. President Lincoln? under the constitution of our forefathers or that known as the Montgomery? On this point our pamphlet expresses itself by implication only, but apparently on the loyal and logical side. Into this question (if there be any among honest and intelligent men) our *Journal* will not enter for fear of politics, and abstains the more readily as the matter appears to be practically settled. F.

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*First Outlines of a Dictionary of the Solubilities of Chemical Substances.* By Frank H. Stover. Part I. Cambridge, Sever & Francis, pp. 232 and appendix.

It is difficult to convey a sufficient opinion of the value of this unpretending writer. Practical and experimenting chemists will alone fully appreciate its value, and from its very nature it is scarcely possible to make extracts from it. The solubility of substances are so intimately connected with their other chemical properties that this work will be indispensable to every one concerned with chemistry.

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#### ERRATA.

"Burlington Tunnel." Vol. xliv., Dec. 1862, page 377, line 10, for "contract price the work was \$60,000," read "\$30,000."

"Strength of Cast Iron Timber Pillars." Vol. xlv. March, 1863, page 180, bottom line, for "supported by pillars 6 inches diam.," read "supported pillars 6 inches diam."

*A Comparison of some of the Meteorological Phenomena of FEB., 1863, with those of FEB., 1862, and of the same month for TWELVE years, at Philadelphia, Pa.*  
 Barometer 60 feet above mean tide in the Delaware River. Latitude  $39^{\circ} 57\frac{1}{2}'$  N.; Longitude  $75^{\circ} 10\frac{1}{2}'$  W. from Greenwich. By JAMES A. KIRKPATRICK, A. M.

	February, 1863.	February, 1862.	February, 12 Years.
Thermometer—Highest—degree,	54.00°	52.00°	70.00°
“ “ date, .	10th.	13th.	23d, 1860.
“ Warmest day—Mean,	46.00	42.2	59.3
“ “ date, .	27th.	13th.	25th, 1857.
“ Lowest, degree, .	5.00	16.0	— 1.0
“ “ date, .	5th.	10th.	7, '55; 8, '61.
“ Coldest day—Mean,	11.17	22.8	5.7
“ “ date, .	4th.	10th.	7th, 1855.
“ Mean daily oscillation,	13.57	10.89	13.41
“ “ range,	7.54	5.55	7.30
“ Means at 7 A. M., .	30.46	28.36	29.25
“ “ 2 P. M., .	37.70	36.00	38.33
“ “ 9 P. M., .	34.04	31.64	32.43
“ “ for the Month,	34.07	32.00	33.69
Barometer—Highest—Inches, .	30.671 in.	30.322 in.	29.671 in.
“ “ date, .	4th.	16th.	4th, 1863.
“ Greatest mean daily press.,	30.537	30.253	30.595
“ “ date, .	4th.	16th.	12th, 1857.
“ Lowest—Inches, .	29.345	29.216	29.065
“ “ date, .	20th.	24th.	23d, 1853.
“ Least mean daily pressure,	29.501	29.454	29.227
“ “ date, .	20th.	24th.	16th, 1856.
“ Mean daily range, .	0.265	0.225	0.224
“ Means at 7 A. M., .	30.031	29.939	29.930
“ “ 2 P. M., .	29.977	29.891	29.882
“ “ 9 P. M., .	30.024	29.922	29.913
“ “ for the Month,	30.011	29.917	29.908
Force of Vapor—Greatest—Inches,	0.322 in.	0.267 in.	0.549 in.
“ “ date, .	6th.	24th.	16th, 1857.
“ “ Least—Inches,	.027	.060	.013
“ “ date, .	4th.	25th.	6th, 1855.
“ “ Means at 7 A. M.,	.142	.130	.140
“ “ 2 P. M.,	.149	.143	.162
“ “ 9 P. M.,	.146	.142	.159
“ “ for the month,	.146	.138	.154
Relative Humidity—Greatest per cent.,	100. per ct.	100 per ct.	100. per ct.
“ “ date, .	19th.	24th.	Often.
“ “ Least per cent,	29.0	44.0	25.0
“ “ date, .	16th.	28th.	21st, 1861.
“ “ Means at 7 A. M.,	77.3	80.4	79.4
“ “ 2 P. M.,	63.5	66.6	64.6
“ “ 9 P. M.,	70.9	77.9	76.3
“ “ for the month,	70.5	75.0	73.4
Clouds—Number of Clear days,*	7	3	8.
“ “ Cloudy days,	21	25	20.
“ Means of sky cov'd at 7 A. M.,	73.6 per ct.	76.1 per ct.	62.6 per ct
“ “ 2 P. M.,	62.9	73.2	60.8
“ “ 9 P. M.,	63.9	61.1	47.1
“ “ for the month,	66.8	70.1	56.9
Rain and melted Snow—Amount .	3.824 in.	4.277 in.	2.899 in.
No. of days on which Rain or Snow fell,	13.	15.	10.4
Prevailing Winds, . . .	N.56°19' W. 139	N.45°0' W. 208	N.69°50' W. 278

\* Less than one-third covered at the hours of observation.

*A Comparison of the WINTER of 1862-3, with that of 1861-2, and of the same season for TWELVE years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude  $39^{\circ} 57\frac{1}{2}'$  N. Longitude  $75^{\circ} 10\frac{1}{2}'$  W. from Greenwich.

	Winter 1862-63.	Winter, 1861-62.	Winter for 12 Years
Thermometer.—Highest degree, .	64.00°	64.00°	71.00°
“ “ date, .	Dec. 15th.	Dec. 10th.	Dec. 2, 1859.
“ Warmest day—Mean,	58.33	54.20	62.80
“ “ date, .	Jan. 15th.	Dec. 9th.	Dec. 19, 1856.
“ Lowest degree, .	5.00	10.00	— 5.50
“ “ date, .	Feb. 5th.	Jan. 5th.	Jan. 23, 1857.
“ Coldest day—Mean,	11.17	18.80	— 1.00
“ “ date, .	Feb. 4th.	Jan. 5th.	Fe. 7, '55; Fe. 8, '61.
“ Mean daily oscillation,	13.07	11.89	12.52
“ “ range,	6.53	5.42	6.74
“ Means at 7 A. M.,	32.22	30.08	29.68
“ “ 2 P. M.,	39.47	37.53	37.72
“ “ 9 P. M.,	35.13	33.16	33.14
“ “ for the quarter,	35.61	33.60	33.51
Barometer.—Highest—Inches, .	30.671 in.	30.462 in.	30.704 in.
“ “ date, .	Feb. 4th.	Dec. 13th.	Jan. 28, 1853.
“ Greatest mean daily press.,	30.553	30.413	30.611
“ “ date, .	Jan. 18th.	Dec. 12th.	Dec. 18, 1856.
“ Lowest, Inches, .	29.127	29.216	28.911
“ “ date, .	Jan. 16th.	Feb. 24th.	Jan. 23, 1853.
“ Least mean daily pressure,	29.298	29.411	29.086
“ “ date, .	Jan. 16th.	Dec. 23d.	Jan. 23, 1853.
“ Mean daily range, .	0.243	0.233	0.218
“ Means at 7 A. M.,	29.963	29.973	29.953
“ “ 2 P. M., .	29.913	29.926	29.911
“ “ 9 P. M., .	29.955	29.955	29.938
“ “ for the quarter,	29.944	29.951	29.934
Force of Vapor.—Greatest—Inches,	0.462 in.	0.390 in.	0.551 in.
“ “ “ date, .	Jan. 16th.	Dec. 9th.	Dec. 2, 1859.
“ “ Least—Inches,	.027	.051	.013
“ “ “ date, .	Jan. 4th.	Jan. 4th.	Feb. 6, 1855.
“ “ Means at 7 A. M.,	.154	.140	.139
“ “ “ 2 P. M.,	.162	.154	.162
“ “ “ 9 P. M.,	.160	.152	.154
“ “ “ for the quarter,	.159	.149	.152
Relative Humidity.—Greatest per cent.,	100. per ct.	100. per ct.	100. per ct.
“ “ “ date, .	Ja. 21; Feb. 19.	Jan. 29; Feb. 24	Often.
“ “ Least per cent,	29.0	23.0	23.0
“ “ “ date, .	Feb. 16th.	Dec. 15th.	Dec. 15, 1861.
“ “ Means at 7 A. M.,	77.9	80.0	79.0
“ “ “ 2 P. M.,	63.4	66.4	66.5
“ “ “ 9 P. M.,	73.5	77.3	76.3
“ “ “ for the quarter,	71.6	74.6	73.9
Clouds—Number of Clear days,*	27 days.	21 days.	25.6 days.
“ “ Cloudy days,	63 days.	69 days.	64.4 days.
“ Means of sky cov'd at 7 A. M.,	64.7 per ct.	70.3 per ct.	63.4 per ct.
“ “ “ 2 P. M.,	63.9	67.5	62.6
“ “ “ 9 P. M.,	55.7	56.1	47.5
“ “ “ for the quarter,	61.4	64.6	57.8
Rain and melted Snow—Amount,	10.077 in.	10.793 in.	9.778 in.
No. of days on which Rain or Snow fell,	35.	35.	31.
Prevailing winds, . . .	N 68° 38' W. 199	N 47° 35' W. 274	N 62° 31' W. 296

\*Less than one-third covered at the hours of observation.



JOURNAL  
OF  
THE FRANKLIN INSTITUTE  
OF THE STATE OF PENNSYLVANIA,  
FOR THE  
PROMOTION OF THE MECHANIC ARTS.

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MAY, 1863.

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CIVIL ENGINEERING.

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*On the Construction of Iron Roofs.*—By J. J. BIRCKEL.

(Continued from page 240.)

From the London Artizan, Oct., 1862.

EXAMPLE 1, illustrates a roof designed and made by Mr. Rankin of Liverpool, for the Hon. C. Napier's Paper Mill at Dartford. The rafters are trussed on the principle of only one secondary truss; they are made of T iron, 3 in.  $\times$  2½ in.  $\times$  ¾ in., and bear a stress of about 5½ tons on the square inch; the ties and braces are all made of flat bars, and the pull on the square inch is, for the lower ties, 6 tons, and for the braces 4½ tons, deduction being made for bolt holes. Ventilation is obtained by means of a lantern roof, the standards of which are provided with louvre blades of rolled iron, No. 20 W. G., and are placed at a suitable angle not to allow the rain to enter; skylights of about 5 feet in width extend over the whole length of the roof on both slopes, the glass resting upon T iron sash bars, 2 in.  $\times$  1¾ in.  $\times$  ¼ in., placed about 12 inches apart, which themselves are supported by angle iron purlins of adequate strength. The lower portions, as well as the lantern roof, are covered with slate, which rests upon angle iron laths, 1½ inch  $\times$  1½ inch  $\times$  ⅓ inch, placed at distances of 10 inches apart, and though very light are of ample strength, the principals being only 6 feet apart. The method of fixing the slates, is done almost as readily as in the examples already commented upon, without the use of boarding, and is not nearly so heavy; nor is it more expensive, for

upon careful calculation we find that the cost of the iron purlins per square foot of roofing is  $2\frac{1}{4}d.$ , and the cost of the square foot of  $1\frac{1}{4}$  in. boarding, is just the same, if the timber be taken at the moderate price of  $1s. 9d.$  per cube foot. On the whole, therefore, this is a neatly-designed roof, and is well-proportioned in its chief parts; as there is no particle of wood in the whole structure, its chances of destruction by fire are very small, for it would require a very hot furnace upon the floor of the building—about 20 feet below the roof—to have any appreciable effect upon the latter.

Example 4 illustrates one of the roofs of the Battersea Locomotive Works, now in course of erection, and was designed, we believe, by Mr. Cubitt. The rafters are made of two angle irons, 4 in.  $\times$   $2\frac{1}{2}$  in.  $\times$   $\frac{1}{2}$  in., bolted together back to back, with a wood packing between them, for convenience of fastening the boarding, which carries the slates. The thrust upon the rafters, if the load be again assumed at 40 lbs. per square foot, is 22 tons, and, taking into account the bending moment, the whole stress upon the square inch is about 10 tons; the tie rod, made of round iron, with suitable bosses forged at the joints, with the vertical ties, has to sustain a maximum pull of  $20\frac{3}{4}$  tons, and, the area being 3.14 square inches, sustains a stress of  $6\frac{3}{4}$  tons on the square inch. The king post, made of  $1\frac{1}{4}$  in. round iron, sustains a stress of 5 tons on the square inch; its junction with the main tie rods, and with the struts of the upper secondary trusses, is made by means of two strong plates, to which the whole of them are bolted, and is one of the neatest arrangements we have yet seen. The struts connecting the king and queen posts are made of T iron,  $2\frac{1}{2}$  in.  $\times$  2 in.  $\times$   $\frac{1}{4}$  in., and sustain a thrust of 4 tons on the square inch; the other struts and vertical ties are proportioned in a similar manner. As the principals are 14 feet apart, there was a necessity for strong purlins, which have been made of two channel irons, 4 in.  $\times$   $1\frac{1}{2}$  in.  $\times$   $\frac{1}{4}$  in., bolted together back to back, with a wood packing between them; and the greatest stress upon them will be about 6 tons to the square inch. On the whole, therefore, this roof is very well proportioned, and as it is very neat in the details of its construction, it may with good reason be held forth in all these respects as an example to be imitated. There is one point, however, in its construction which is open to very grave objections, namely, the introduction of the wood packing and planking for convenience of fastening the slates. The weight of iron contained in principal and purlin forming one bay of the roof, is about 32 cwt., and the weight of wood in the same space is about 33 cwt., both materials being, practically speaking, in equal weight. Now, 33 cwt. of wood can develop a quantity of heat equal to that developed by about 16 cwt. of coke, and these, at the ordinary rate of consumption in a cupola, could melt down at least 120 cwt. of pig iron. Should this roof, therefore, by any mischance take fire, if not discovered in time, nothing could save it from utter ruin. It is, of course, not contended that the whole of the iron would be melted down, but the great proportion of wood in contiguity with the iron can leave no doubt upon the minds of our readers that, even should the roof not

come down with a crash, the whole must be so much injured as to be quite unsafe, and unfit for further use. How any one can deceive himself into the belief that he has made a fire-proof building, when he has covered it with a roof like this, is to us a matter of great mystery. But, if the roof is not to be fire-proof, why, we ask, make all its vital parts of iron, or why introduce any iron at all, when it is universally admitted that wooden structures of this kind, notwithstanding the great progress in the manufacture of iron, still remain much cheaper than iron ones? The roof, however, was meant to be fire-proof, and the wood, which in reality forms no part of it, is a matter of secondary consideration only; it is a dead weight which only keeps the slate in its place; its destructive power has not been taken into consideration, and as we shall have occasion presently to show that it can be very well dispensed with, we may safely say that its presence here is a decided mistake.

Example 12 illustrates the roof of a shed at Chatham Dockyard, and was designed by the engineers of the Admiralty; it is covered with corrugated iron, and, in consequence, has a very small rise, the angle being 1 in  $4\frac{1}{2}$ . With a load of 40 lbs. per square foot, we should have  $\frac{1}{2}w = 4$  tons, and the maximum stress on the rafter would be  $22\frac{1}{2}$  tons, to resist which we have a T iron 5 in.  $\times$  5 in.  $\times$   $\frac{1}{2}$  in. equal to 5 square inches in section, and causing a stress of  $4\frac{1}{2}$  tons to the sq. inch; this, however, does not take into account the bending stress, although it so happens that at the foot where the thrust is greatest, the purlin sits very nearly at mid distance between two consecutive centres of support. Farther up, the purlins sit very nearly upon the centres of support, and as the assumed load of 40 lbs. is considerably greater than it ever will be, there is no doubt that the rafter will be quite strong enough; the maximum pull on the tie rod would be 19 tons, and has an area of  $3\frac{1}{2}$  square inches, deduction being made for bolt holes, thus occasioning a stress of about  $5\frac{3}{4}$  tons on the square inch. The pull on the king post is about  $7\frac{1}{2}$  tons, its area  $1\frac{1}{2}$  square inches, and the stress upon the square inch about 3 tons. So far, therefore, this roof is very fairly proportioned; but upon examination of the secondary trusses, we find that the strengths of both struts and vertical ties are out of all reasonable proportion; the pull on the queen rod, for instance, is  $2\frac{1}{2}$  tons, its area  $2\frac{1}{3}$  square inches, and the stress upon the square inch  $1\frac{1}{7}$  tons, while the thrust upon the strut connecting the queen and queen rods is  $3\frac{1}{2}$  tons, with an area of 4 square inches, the stress on the square inch being  $\frac{7}{8}$  tons. The succeeding struts and ties are similarly proportioned, and the whole of them might have been reduced by the amount of one-half their strength at least. We must also remark that the vertical tie, connecting the upper centre of resistance of the lower truss with the main tie rod, is perfectly useless, as it gives no additional rigidity to trussing. The tie rods, it will be noticed, are made of flat iron of uniform width and thickness, and are a little heavier than they would be if they had been made of uniform area; but as this arrangement avoids all expense of smithing, the final cost is found to be less, in spite of the additional

weight of metal. The struts of the secondary trusses are jointed to the rafters by means of two straps, and are dipped at their lower ends between the main tie rod, which is double for the convenience of making the joints. The corrugated iron covering is carried by means of T iron purlins 5 in.  $\times$  4 in.  $\times$   $\frac{1}{2}$  in., which are stronger than they are really needed, the principals being only 9 feet apart. The shed is lighted from above, by means of two skylights, the glass being carried by T iron sash bars, 2 in.  $\times$   $1\frac{1}{2}$  in.  $\times$   $\frac{5}{16}$  in., placed about 12 inches apart, and provision is made for ventilation by means of a louvre roof, raised sufficiently to allow of the free circulation of air. Before concluding our observations on this example, and although we do not intend to enter into the discussion of the stability of the supports of roofs, we must call attention to the very peculiar case of the pillars supporting the one under consideration. Professor E. Hodgkinson has positively proved by his experiments that pillars with flat bases, of ample area, offer three times the resistance of pillars rounded at the base, the height and transverse section being the same; yet, and notwithstanding this well known fact, have these been almost tapered down to a point:—for what rational purpose we are at a loss to find out.

After careful examination of the examples submitted, we are enabled to draw the inference that in roofs chiefly made of iron, there results no material saving from the introduction of wood for the convenience of merely fastening the covering. And where there are no special causes for the use of wood, as, for instance, a desire or necessity of preserving, as far as possible, an even temperature inside the building, we would strongly deprecate the use of wood, as being an inherent source of danger to the structure of which it forms part. The great calamities which have occurred during the last twelve months are in themselves alone sufficient to justify us in raising a warning voice against the use of a material so suicidal—yet, it is true, so easy and so universal in its adaptation.

**CIRCULAR ROOFS.**—From reasons of taste,—and in the case of roofs of very large spans, most probably from reasons of economy,—engineers are sometimes induced to construct roofs in the shape of an arch whose outlines are fixed generally as much by the laws of æsthetics as by those of statics. In such roofs the principal assumes pretty much the character of a linear arch, stiffened by means of a system of trussing, as in the case of a triangular roof; but as the principles of stability of the arch itself have, until within a comparatively recent period, been but imperfectly understood by scientific men, and still remain a matter of great mystery, at the present period, to the greater part of that very respectable body of men called practical engineers, so in proportion to the want of a proper knowledge of this subject, have these gentlemen gone astray from truth in their designs of arched roofs.

One of the earliest structures, nay, we believe the first structure of this description built since the introduction of iron into the architecture of roofs, and which (notwithstanding the inaccuracy of its design as a trussed frame to be pointed out presently) has gained a very great

celebrity—is the roof over the Lime Street Railway Station at Liverpool—and as it has withstood the destructive action of a lapse of time of some thirteen years, it may reasonably be affirmed, also, that it is deserving of that celebrity. The fact, however, of any structure resisting the action of time, and accomplishing the objects for which it was called into existence, is no proof of its being a correct embodiment of scientific truths, but simply proves that so far the structure has proved strong enough; neither should this fact exempt it from a critical analysis, the result of which might prove very useful in future practice.

This roof is described by its designer, Mr. Turner, “as consisting of a series of segmental principals or girders, fixed at intervals of 21 ft. 6 ins. from centre to centre, trussed vertically by means of radiating struts made to act upon the rafters by straining the tie rods and the diagonal braces. Each principal or girder is composed of a wrought iron deck beam 9 ins. in depth, with a plate 10 ins. wide and  $\frac{1}{4}$  in. thick, riveted on the top; the upper flanch of the deck beam is  $4\frac{1}{2}$  in. wide and  $\frac{1}{2}$  in. thick; the lower flange is 3 ins. wide and 1 in. thick. The beam is strengthened at the haunches for a distance of 27 ft. from the springing, by plates 7 ins. broad, and  $\frac{7}{8}$  of an inch thick, fastened together by rivets.”

Here, therefore, the principal is distinctly described as an arched lattice girder, whose compression and tension flanches are connected by means of a succession of radial struts, and of ties sloping from the centre towards the walls or supports; the depth of the girder diminishes from the centre in the direction of the supports, until the compression and tension flanches meet at each of the extremities. But for this latter feature in its construction, it would be like an ordinary lattice girder, with vertical struts and ties sloping from the bottom of one strut to the top of the following one, in the direction of the supports; the fact of the two flanches meeting, however, alters the case materially, inasmuch as it compels the last sloping rod or tie, as Mr. Turner would have it, to fall upon the compression flanch itself for its support; and when we remember that the strains upon those ties accumulate from the centre of the girder where they are smallest, towards the ends where they reach their maximum, if we construct the diagrams of stresses on this hypothesis, and on the assumed load of 40 lbs. per square foot, we find that the last sloping rod, if it acts as a tie, exerts a component transverse strain upon the rafter or compression flanch, equal to about 35 tons, at a distance of 11 ft. from the wall or column. As the actual direction of that supposed pull is from the wall or columns, and as the principal rests only loosely upon them, we do not see on what principle of dynamics or of statics it is not pulled away from its supports and precipitated into the area below; for hitherto we have been taught, and we have believed, that wherever there is a pressure not balanced, there must be motion in the direction of that pressure; and in the case under consideration, if there is a pull upon the said sloping rod, it cannot be neutralized by the re-action of the wall, for the rafter is the only medium which could connect it with

the wall. It is not supposed to be neutralized by the tension flanch or tie rod, for this could only be effected by a compression strain on the tie rod; and to suppose this would be looked upon by the designer of the roof himself as an absurdity. The only resistance that we can perceive is that offered by the rafter and the tie rod to bending and doubling up in the centre, a resistance which, considering their dimensions, would be of little avail against a component horizontal pull of some 160 tons, with a leverage of 20 ft.; this supposed pull, therefore, could only bring about a dynamical equilibrium, the effect of which must be to bring down the roof.

We think, however, that it will not be difficult to prove that those supposed sloping ties do not act as ties at all, but act as struts; and that the supposed radiating struts act as ties. To this effect we will, for an instant, suppose the principal to be without any weight of its own, and free from all external load; in fact, we will suppose it to be a linear structure capable of resisting any pressure we may choose to apply. At the points we will now apply certain pressures, which to simplify the case, we will suppose to be normal to the curve of the rafter, and of equal intensity on both sides. It is evident that these pressures will produce compression on the portions of the rafter, and on the sloping rods, which compression strains are balanced by a tension strain on the parts of the tie rod; the radial components of the strains by means of the roots are carried to the points where they produce results similar to those produced by the pressures, namely, compression on the portions of the rafter, and on the rods, which are again balanced by a tension strain on the portions of the tie rod, and the same fact reproduces itself upon the successive trusses until the summit of the roof is reached, the several strains accumulating progressively upon the rafter and the tie rod as we approach the extremities of the principal. If now we apply certain pressures at each of the centres of resistance, these respectively will add themselves to the pressures transmitted from each preceding centre of resistance to the radial rods by means of the sloping rods, and the system of trussing thus naturally reduces itself into a series of radial or *quasi* vertical ties connected by means of sloping struts, or king and queen post system of trussing.

To the analysis which has led us to the above conclusion, and to the objection which, no doubt, will be raised by the more superficial inquirer, that if the ties of the Lime Street roof are struts in reality, the roof could not have stood the test of time, we shall give the ready answer, that the fact of the roof having stood this test only proves that, up to the present time, those struts have been able to do their work of resistance, and that the rafter itself, being a strong beam, required little trussing to enable it to do its work. Indeed, if we construct a diagram of stresses on the hypothesis of the principal being a polygonal frame trussed on the system of the king post roof, with an assumed load of 40 lbs. per foot, we find that the stress upon the rafter is a little less than 4 tons per square inch at the foot, and about 8 tons in the centre of the bay; the maximum stress on the sloping struts is  $6\frac{1}{2}$

tons, and that on the main tie rods about  $9\frac{1}{2}$  tons per square inch, which figures are a clear proof of the correctness of the remarks we have just made. This roof, therefore, if modified in the manner we have suggested, will at all times be an elegant example to imitate; and though we have referred to it as a theoretical blunder (a blunder which will be readily excused when it is remembered that at the time of its construction the theory of structures had not yet been rendered so easily accessible as it is now, with the help of such works as those of Rankine and Mosely), yet it is an example of iron roof construction well worthy of recording, because it represents a great stride in advance of what had previously been effected in roof construction, and must be looked upon as a bold and practically successful conception of the mind of man.

No sooner had the Lime Street roof been fairly tested, than engineers at once entertained the possibility of still greater achievements, and in the year 1853, Messrs. Fox and Henderson constructed the roof over the New Street station at Birmingham, with a maximum span of 212 feet, being 60 feet larger than that of the Lime Street roof, and we believe, up to this time, the largest span known. In its general features, the design of the principal of this roof, resembles much the one previously commented upon. The rafter consists of a plate beam 15 ins. deep, with top and bottom flanches of L iron 6 ins.  $\times$  3 ins.  $\times$   $\frac{1}{2}$  in. thick, and midweb  $\frac{1}{16}$  thick; the main tie rod is round, 4 ins. diameter throughout, and with the only difference of the so-called struts being vertical instead of being radial, and of its having crossed diagonals instead of single ones, it may be said to be a copy of the former. Our arguments, therefore, put forward in discussing the nature and merits of the trussing in the Lime Street roof, would apply here again, and would lead us to the same conclusion, namely, that the re-actions take place as in the case of the king post system of trussing, and that the principal should have been constructed according to this system.

In some of its details it differs greatly, and we think unfavorably, with the former; the succeeding lengths of the tie rod, for instance, are connected by being screwed into a wrought iron coupling box, a method very expensive in the first stage of preparing the work, and very troublesome in the subsequent stage of putting it together; the so-called vertical struts are made of four light L irons, distanced by means of cast crosses in such manner as to be farther asunder in mid-length of the strut than at the ends, and assembled by means of bolts passing through those crosses, the whole, it must be perceived, requiring much labor, and on that account being very expensive. The sloping struts having been supposed to act as ties, are comparatively weak, but as there are two diagonals in each bay riveted together at the points where they cross, this defect is greatly lessened, because the length of the actual strut, owing to this circumstance, is greatly reduced.

The design of the roof having been made upon an erroneous assumption, we shall not enter into an analysis of the strengths of the seve-

ral parts of the principals, but shall simply state that, had its designer started from a correct hypothesis, it would, most undoubtedly, have been considerably lighter.

We must notice also that the purlins are made of wood trussed with iron, a fact which we cannot consider an improvement upon the Lime Street roof, either on the score of security or on that of elegance. We have, however, thought proper to introduce it to our readers, because a structure which has the merit of being the largest of its kind in existence must, at all times, be a subject of much interest to all professional inquirers.

Mr. Fairbairn, who was one of the parties consulted about the practicability of Mr. Turner's design, and whose opinion at the time was in favor of it, seems to have given the subject upon which we are engaged his early attention, and, with his habitual sagacity, seems to have arrived at a correct comprehension of it; for in 1857, he caused the boiler yard, now belonging to Messrs. Fairbairn & Co., to be covered in with an arched roof, consisting of two spans of 50 ft., with principal trussed on the system according to which, in the roofs previously analyzed, we have demonstrated the re-actions described to take place. We would not, however, have our readers believe that this is the only way to truss an arched principal correctly, for it might be trussed with theoretical propriety according to our first paper on roofs; but we think that the king post system has a claim to preference, because, on the one hand, it seems to us the more elegant of the two, and because, also, the thrust on the upper portion of the rafter, as we have seen, is considerably less with this system than with the other, a circumstance which here is of much importance, because the almost horizontal position of that portion of the rafter causes the bending stress to be considerably larger for the same vertical load than it is at the foot of the rafter.

If, now, we construct the diagram of stresses with a due regard to this particular feature of the problem that the stress upon any portion of the polygon is represented, both in the primary and in the secondary trusses, by a line drawn parallel to that portion of the polygon, from the point of intersection of the extreme lines closing the diagram of the particular truss of which that portion of the polygon forms part, we find that the rafter which is made of T iron  $3\frac{1}{2} \times 3\frac{1}{2} \times \frac{3}{8}$ , sustains a stress of about 6 tons on the square inch, and is so small because the purlins have been placed so close to the several centres of resistance as to render the bending stress almost nil; the tie rod is made of  $1\frac{1}{4}$  ins. round iron, and sustains a pull of  $5\frac{1}{3}$  tons per square inch; the stress on the struts, also, of the upper and lower secondary trusses is about one ton per square inch; the struts are made of T iron, respectively  $3\frac{1}{2} \times 3 \times \frac{5}{16}$  and  $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$  in. section. The roof is covered with corrugated iron; the principals, which are 11 ft. apart, are carried by strong wrought iron beams, which themselves rest upon the end walls of the building, and between those on two strong cast iron columns 18 ins. diameter, thus causing as little obstruction as possible on the floor below; the shop receives the light from a louvre roof,



glazed in the whole of its width of about 16 ft., and by means of which ample provision is made also for ventilation. On the whole, therefore, this roof is very well proportioned, and in its place it looks exceedingly elegant.

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*Description of the Drainage of the Borough of Dundee.*

By Mr. JOHN FULTON.

From the Lond. Civ. Eng. and Arch. Jour., March, 1863.

It was stated that, previous to 1851, this town was in a most defective condition, in a sanitary point of view. In that year the borough was brought under the powers of the General Police Act for Scotland, but owing to a defect in the drainage clauses of the Act, the sewerage was not commenced until 1856. It however progressed steadily after that date, and was entirely completed in five years, at a cost of £52,000.

In designing this drainage one primary object kept in view was the application of the sewage to some useful purpose, although in the meantime it was allowed to flow directly into the river Tay. Accordingly the whole drainage so far as practicable had been carried to one point—the outlet of a sewer previously constructed by the Harbor Trustees, to intercept the drainage of the town, and prevent it from entering the docks or tidal basins. This sewer had a fall of 1 in 400, was 7 feet high by 3 ft. 9 ins. wide, and its discharging end was 8 feet below the level of mean tide. The sewage discharged by it, in dry weather, measured 2 feet in depth, and during storms 6 feet. The velocity in the former case was 65 feet per minute, and in the latter 116 feet per minute. The drainage had been carried out by a combination of brick sewers and salt-glazed, fire-clay socket pipes, of dimensions suitable for the discharge of the sewage and the flood waters combined. The whole of the brick egg-shaped sewers were provided with invert blocks of glazed fire-clay. The streets drained by tubular sewers were chiefly those at right angles with the river, which were the steepest and therefore the most suitable for tubular drains. The proportion of brick sewers to tubular drains was as 1 to 2, the total length of the former being 10 miles, and of the latter 20 miles; and their cost was nearly as 3 to 1, the average of the former being 33s. and of the latter 13s. per lineal yard. The leading or intercepting sewers had been made from 12 to 18 inches deeper than the lateral and branch drains, with the view of preventing the ends of the latter from silting. It had been found that, with a fall of 1 in 600, the earthy and more soluble matters were carried off by the ordinary rain-fall and sewage, by a proper system of flushing; but a deposit of sand was left behind in all sewers having no greater fall than 1 in 600. It was not apprehended that much annoyance would arise from this cause, as none of the sewers had a less fall than 1 in 700. Passages with manholes had been carried up to the street level from both the brick and the pipe drains, at the junctions of the leading and lateral sewers, and at distances of 40 yards along each sewer. The junctions for house drains and gullies, con-

sisting of ordinary socket pipes with beveled ends to suit the form of the sewer, were built in as the work proceeded. In the case of tubular mains, socket-junctions having an acute angle were placed at intervals of from 30 to 60 yards apart, or where required for branches, or for gully drains meant for the reception of rain water only. The gases of the sewers were prevented from escaping through the gullies by valves made of stone, and hung with copper links, placed in one side of a small cesspool, the bottom of which was 10 inches below the lower sides of the valves. This form of gully had been found very suitable in Dundee, as the valves freely passed the flood waters, while the cesspools retained all the heavier particles of road detritus. The branch drains had no other trap than the syphon with a cleansing screw, which was placed in immediate contact with the sink, water-closet, or grating used for the reception of soil water, and in such a position as to be easily accessible.

As the water supply was in the hands of a company, it was thought that the expense of flushing the sewers from this source would have been too great. Consequently the plan adopted was to intercept the sewage, and to turn it into any sewer, or series of sewers, that might be desired. This was accomplished by means of cast-iron gates, placed at the junctions of sewers and immediately under manholes, and in this way the greater portion of the sewers had been made self-cleansing.

The flushing gates were 15 inches deep only, and they answered the purpose of overflow weirs, preventing the sewers during floods from being subjected to pressure, by allowing the surplus contents to flow into subsidiary outlets, thus equalizing the flow of water. In sewers having a less fall than 1 in 600, it was found, as already explained, that there was a tendency to the accumulation of sand; and in pipe drains with even a greater fall, where the ordinary house drainage only existed, sand also accumulated. This occasioned the invention of a cleansing apparatus. When a sewer was to be cleansed, a windlass, containing about 45 yards of iron chain, was placed over each of two adjacent entrance ways, 40 yards distant from each other. A series of iron tubes was then put together at the bottom of one manhole, and was pushed by hand to the next, where they were again unscrewed as they were drawn through. The chain being attached to the last rod was by this means carried along the sewer, and affixed to the cleansing tool in connexion with the other chain and windlass. As the matter to be removed usually consisted of hard sand, a tool was first attached to the hooks of the chain, in order to plough or break it up. When this had been sufficiently done, a scraper formed of strong plate iron, and furnished with small wheels or movable axles on its lateral and lower edges, was next drawn through. It usually required to be moved backward and forward several times before the required cleansing was complete. In the case of tubular sewers the plan adopted was somewhat different. The scraper did not require any wheels, and the plough was attached to the end of the entering rod. The cost of cleansing sewers by this mode was on an average, for tubular drains one

penny, and for brick drains twopence per lineal yard. No sewer had hitherto required to be cleansed oftener than once in twelve months.

No ventilation whatever had been applied to the sewers in Dundee, and none was contemplated; for although a length of 30 miles of main sewers, and nearly as many miles of branch drains, all closely trapped, had been in use for several years, not a single complaint had been made regarding foul emanations from them. The sewers were kept free of all silt, except sand, by the flow of the ordinary sewage and rain-fall, regulated by the flushing gates, so that no putrescent substances were retained in the sewers or drains, to fill them with deleterious gases, and to poison the inhabitants. It was believed it was only where sewers were badly constructed, as regarded their form and water-run, that putrid matters were retained in them to bring disgrace on the very name of drainage. It was thought that no sewer under 10 feet in height ought to have an invert of more than 9 inches radius, and that a radius of 6 inches was quite large enough for the invert of any ordinary sewer. When the sewage was confined to such a small compass as this its scouring power was very great; and if care were taken to have the invert blocks laid to a straight line, there would be but little silting, even with a slight fall.

In conclusion, it was stated, as the result of the drainage of the town, so far as could at present be ascertained, that as compared with former years a decided decrease had taken place in the rate of mortality.

Proc. Inst. Civil Eng., Feb. 10, 1863.

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### *International Exhibition.*

From the Lond. Mechanics' Magazine, Jan., 1863.

#### CLASS X, SECTION A—JUROR'S REPORT.

(Continued from p. 233.)

The application of the hydraulic press for the purpose of raising great weights has long been known and adopted in numerous instances, and latterly very extensively by the late Mr. Robert Stephenson, for raising the large tubular girders composing the Britannia and Conway bridges; a similar idea has been conceived by Mr. Edwin Clark, C.E., and applied in a very ingenious manner for raising floating pontoons, which are made to answer the purposes of dry docks for constructing, examining, or repairing vessels. The operation is very simple. A space of water is enclosed, sufficient for the required pontoon, or floating dock, around which are firmly fixed a number of hollow iron columns, in each of which is a hydraulic press and piston, having chains attached to them; these chains are attached at the other end to transverse wrought-iron girders at the bottom of the enclosed water space; the wrought-iron pontoon, which is to carry the vessel, is then floated between the columns, and sunk on to the girders by admitting water into its compartments until it rests upon the bottom of the enclosed water space; the vessel intended to be repaired is then floated over the pontoon, and is placed accurately above it by means of guides; the girders and pontoon, with the vessel upon it, are then raised by

the hydraulic presses, worked by a steam engine and pumps, which act upon the pistons and the chains attached to them, to the cross girders, and as the pontoon rises with the vessel upon it, the water runs freely out of the compartments of the pontoon, and, when the whole is clear, the valves are screwed down from the inside, and the pontoon and vessel are floated away into a basin, and another pontoon is placed in readiness for another similar operation, which generally occupies, for a very large ship, about forty-five minutes. Thus one hydraulic apparatus, with its necessary upright columns, cradle, and basin, or dock space, will answer the purpose of as many dry docks as there are pontoons; and when a vessel has been repaired, the supporting pontoon is again floated over the transverse girders, the valves are opened, and the pontoon sinks gradually, thus leaving the vessel afloat and ready to be taken away. This ingenious adaptation of the hydraulic press is calculated to be very extensively useful in many localities, and to Mr. Edwin Clarke, E.C. (United Kingdom, 2255) a medal has been awarded, for the novelty and general utility of the application.

A large wrought-iron floating dock has been designed, and is being constructed for the Spanish Government by Messrs. G. Rennie and Sons. It is 350 feet long, 105 feet wide, and  $37\frac{1}{2}$  feet high, and it will draw, when a vessel of the largest class is in it, about 10 feet. This dock is constructed nearly upon the same principle as the old Dutch Caramel Floating Docks, but is much more complete. It is hollow, is divided into compartments, and is emptied with pumps, worked by a steam-engine placed on the floating dock, so that either by admitting, or by pumping out the water, it can be lowered or raised as may be required, and it can thus be rendered available for any class of vessel. To Messrs. G. Rennie and Sons has been awarded a medal by the Jury of Class XII. for the completeness of the arrangements and the good workmanship of this important construction.

Floating docks upon this as well as upon Clark's system are no doubt very valuable, but it may be a question whether they are likely to supersede the slip system, or that of drawing the vessels out of the water, which can be made equally valuable in certain localities. It is true that the latter system requires that the lower end of the slip should be carried down to the greatest depth, at which a light ship of the largest class can be brought to the lower end of the slip; this cannot be taken at less than sixteen to twenty feet, and to effect this in seas where there is no tide must be attended with considerable expense; and laden vessels cannot, as in Rennie's and Clark's systems, be drawn up, examined, and lowered again within a few hours. Anything by which the old system of heaving down vessels of the ordinary class can be avoided merits attention, as that process is always attended with expense, inconvenience, risk, cost, and delay. The re-introduction of floating docks, on improved principles, has also induced attention to Morton's patent slip, which is now again being brought forward with considerable improvements. All these systems are valuable and useful, and can be brought into the public service where the fixed

dock system is considered too expensive, or where the localities are not calculated for such extensive and weighty structures.

*Compensating Reservoirs, &c.*—With regard to the fourth division—the compensating reservoirs for supplying rivers and streams during summer and dry seasons. This is a most important and valuable system, and it has now become an absolute necessity, as, in consequence of the present superior system of land drainage, a greater proportion of the rain-water which falls upon the land is discharged into the rivers, and is carried off almost immediately after it falls, so that in summer and in dry seasons the lands frequently suffer for want of moisture; the navigation is impeded, and the supply of water for irrigation and for domestic purposes is diminished. Moreover, as sewage matter is now generally discharged direct into the nearest water-courses, the small quantity of water in them in times of drought becomes polluted to such an extent that it is unfit for use, whilst the malaria arising from it is liable to produce disease. The great object, therefore, is to obtain a thorough command of water, so that the land may be properly drained, the sewage be carried off effectually, and that there may be at all times an ample supply of good fresh water for navigation, irrigation, and domestic purposes. A system of compensating reservoirs, established in the most convenient places, along the line of, or adjoining the valleys, through which rivers pass, so that the desired quantity of water may be stored in them during the periods of rainfall, and be discharged again by means of proper sluices, into the rivers and other channels, where required during the summer and dry seasons, is evidently the only proper plan to obviate the serious evils above mentioned, and to combine all the desiderata of complete drainage, sewage, navigation, irrigation, and domestic water supply. This system was largely adopted by the ancients in the valley of the Euphrates, India, and elsewhere, and it contributed largely to the wealth and prosperity of those countries wherein it was practised. It redounds greatly to the credit of the French Government and their engineers that this system has been introduced into France with such complete success in many places.

The introduction of this system into Great Britain, has long been advocated by English engineers, who have devoted their attention to the subject, and it cannot be much longer delayed, as works of this kind are now imperatively demanded, both in a sanitary and economical point of view.

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*Description of the Sewerage and Drainage Works, at Newport Monmouthshire.* By Mr. ALFRED WILLIAMS, Assoc. Inst., C.E. F.G.S.

From the Lond. Civ. Eng. and Arch. Journal, March, 1863.

It appeared that, prior to the construction of the works which formed the subject of this communication, several miles of sewers and drains had been built at different times, but mostly in an imperfect manner, and without regard to any general system. There was nine open outlets into the river, varying in level from 5·4 feet to 12·9 feet

below high water of ordinary spring tide; and the tide flowed up the sewers, and sometimes flooded the cellars and basements.

In 1856, the author received instructions from the local board of health to prepare a plan for the drainage of the borough, which he so arranged.—First, that the outlets were reduced from 9 to 4, by intercepting sewers necessary for the drainage of the districts through which they passed; power being retained to use the abandoned outlets, without additional works, should circumstances require it. Secondly, that the sewage of two-thirds of the town might be brought to the lowest outlet down the river, near the extremity of the borough; and by a further expenditure, if events should justify it, the greater portion of the remaining third might be carried to the same outlet, which was a new one selected at a suitable point for the distribution of the sewage matter in a liquid form, or for its conversion into solid manure. Thirdly, that the gradients were generally favorable, considering the level of the great portion of the district, the flattest inclination of any new sewer being 1 in 488 near the lowest outlet, and nearly half the entire length of the new sewers being steeper than 1 in 100. Fourthly, that no cost should be incurred in works, or water for flushing, the plan being so laid out as to take advantage, for cleansing purposes when required, of the land-water, and the waste water from the canal, ponds, feeders, &c., in the town, and water being also obtainable, on an emergency, from the water-works at any point.

The plan comprised about seven miles of new brick sewers, varying in height from 14 inches to 4 ft. 6 in.—all above 14 inches being egg-shaped and narrow at the invert—with outlet works; also of a sufficient number of entrances with ventilating shafts, and of street gullies. The contract for the works was let to Mr. John Phillips, and their cost had amounted to £ 11,862, or about 14 per cent. under the engineer's estimate, which latter was less than the average of nine tenders received for the works.

With reference to the numerous outlets it was mentioned that the case of Newport was exceptional, the size of the river and the extraordinary rise of tide rendering the amount of sewage matter discharged into it comparatively insignificant. Of the four outlets two were old, where a large quantity of land-water was discharged. For the remaining outlets, two points were selected suitable for the utilization of the sewage, if that should be found practicable, and not near any houses—where the sewage would have a short and steep run into the stream at low water, and where only short lengths of pipes would be required. When the outlets were closed, the sewers had for a time to act as reservoirs: but no practical inconvenience was found to arise from this, means of ventilation being provided.

The author did not consider it advisable to use stoneware pipes as main sewers, having regard to the circumstances of the town, the existing works, the relative cost of brickwork and pipes, the quantity of debris washed from the roads into the sewers, the difficulty of preventing improper interference after construction, &c. Under the Newport contract, the cost of radiating brick sewers 14 inches diameter and  $4\frac{1}{2}$

inches thick at a depth of 10 feet, with a junction pipe for every house, was 7s. 7d. per lineal yard. This was about the same as a pipe 12 inches diameter, well laid, with junctions. Sewers 2 ft. 6 ins. by 1 ft. 10 ins. of brickwork,  $4\frac{1}{2}$  inches thick, similarly constructed, and large enough for a man to pass through, cost 11s. per lineal yard. The author generally recommended brick sewers not less than  $2\frac{1}{2}$  feet high for all important lines, excepting where the fall was very great; and he confined the use of pipes to house drainage, for which they were admirably adapted, to short branch sewers on steep inclinations, and to conduits for fresh water.

The bricks were all made by machinery,—the clay having been previously passed through a pug mill,—some by steam and others by hand-power. They had a small longitudinal hollow, which reduced the thickness of the clay, and without materially weakening the brick, caused it to be more dense and more easily burnt. For the 6-inch work, the bricks were 12 inches long by 6 inches deep and  $3\frac{1}{2}$  inches thick; and they were found to effect a large saving in many of the sewers, where otherwise two rings of  $4\frac{1}{2}$  inch work would have been used. The bricks for the 6 inch and  $4\frac{1}{2}$  inch rings were all made to radiate, to suit the invert, side walls, and crown of the several sized sewers; and in order to distinguish readily the different radii, as well as to afford a key for the mortar, grooves varying in shape and number were made in the sides of the bricks. The inner and outer surfaces were curved, so that when well put together a very accurate sewer was formed.

The sewers near two of the outlets having to act as reservoirs for about three hours at spring tides, as previously mentioned, their ventilation was effected by a large number of man-holes and ventilators combined, which were placed in open parts of the centre of the roads and streets at a cost of £4. 10s. each complete.

The rate of mortality in Newport in 1850, previous to the adoption of the Public Health Act, was 30.3 per thousand, whilst for the two years ending Michaelmas, 1861, it was rather less than 20 per thousand, or below the average of England and Wales. This very large decrease was, no doubt due, under Providence, to efficient drainage and water supply, to the prevention of over-crowding, and to other sanitary measures.

Proc. Royal Society, Feb., 10, 1863.

For the Journal of the Franklin Institute.

*Papers on Hydraulic Engineering.* By SAMUEL McELROY, C. E.

(Continued from page 228.)

### No. 3—PUMPING ENGINES.—(Continued.)

*General Conclusion.*—Having made a distinct analysis of the three divisions of a pumping engine, viz: the pumps, engine, and boilers, it remains to group the several parts together, in some discussion of joint performance.

As to the pumps of large engines, we have noticed the advantages of double-beat valves, the usual defects in suction arrangement and

lift, the relative merits of plungers and buckets, the benefit of direct lines of supply and delivery, and of large openings, the fallacy of uniform motion and short strokes, the doctrine of uniformly variable motion, of loss of action of combined pumps, of force main size and line, and of air chambers.

The single-acting engines have been noticed as to their arrangement in general and detail, their rank as standards of all other classes, their merits in comparison with double-acting engines, the defects of crank motion, the principles of high steam, expansion, momentum, and the defects of combined engines.

The boilers have been noticed as to their varieties of arrangement, furnaces, flues, and tubes, proportions, appurtenances, fuel, general management and comparative economy.

From this subdivision of this subject, in which each part exerts an individual effect on the general result of economy, durability, and perfection of operation, the prominent lesson which is derived, is that of the benefit and necessity of simplicity in form; the highest results being evidently contingent on the most direct and facile lines and method of motion, and the least complicated design.

Careful construction in adaptation to intended work; careful workmanship; and careful management solve the problem of maximum duty, in these three divisions, jointly and severally.

*Problem of Duty.*—As the coal fed to the furnaces, in one division, and the water delivered to the reservoir in another, form the basis of calculation in engine duty, it is evident that each part must give a maximum result in order to ensure a maximum in the whole combination; and that the engine should be perfectly adjusted in itself to its work, without embarrassment from the boilers on one side, or the pumps on the other. It is also plain that a perfect combination in timid or incompetent hands cannot develop its true measure of results. Educated design is often overruled in the workshop, and seriously injured in anticipated results. If the history of most of our prominent engines was faithfully written, it would utter no unmeaning verdict against those who are "wise above what is written," and foolishly obstinate in that arrogance of opinion, which too often characterizes the half educated. Equally true is it, that the best engines often come short of their real capacities through equally obstinate and prejudiced handling.

*Theoretical Duty.*—Taking the value of the carbon and hydrogen in one pound of coal, as equal to an evaporation of 14.25 pounds of water, and taking the steam at atmospheric pressure we have the following duty in the boiler.

14.7 pounds per square inch,  $\times 1700$  (relative volume)  $\times 144$  square inches  $\times 14.25$  pounds of water evaporated  $\div 61.13$  pounds of water per cubic foot at  $212^{\circ} = 838,819$  pounds raised one foot per pound of coal.

At one-third cut-off this duty, multiplied by 2.099 = 1,706,681 foot-pounds, and at one-tenth cut-off, for the ratio of 3.3 = 2,768,102 foot-



pounds, and these amounts vary with various ratios of expansion. They will be also increased by a higher range of boiler pressure, in some degree.

*Practical Duty.*—As it is a matter of record that some Cornish engines at the mines have repeatedly exceeded *at the pumps* the above full steam duty of 838,819 foot-pounds, being reported for monthly averages in certain cases, at 870,000, 885,000, 914,000, 954,000, 961,000, 1,019,000, 1,075,000, and in the experiments of Mr. Wicksteed, at 1,038,037, for 1·12 lbs. coal, in one trial of 117·6 hours, where the evaporation was 8·524 lbs. of water per pound of coal, it follows as an experimental demonstration that there must be a very positive and important gain by expansion, since none of the boilers of these engines yield above 70 per cent. of the theoretical value of the coal, and there are inevitable losses between the boilers and the pumps, by steam radiation, condensation, friction, &c., and engine and pump friction.

In calculating the duty of the Cornish mining engines for the monthly reports, which have been made for many years past, the total amount of coal in bushels, which has been used, and the total number of pump strokes registered form the basis of the report. The coal weight per bushel, has been usually assumed at 94 lbs.; and the total contents of the several pumps, into their different lifts, determine the foot-pounds of water delivered. This process credits the duty account with the item of pump loss of action, but it neglects that of pump friction, the actual lift being taken. It is for the interest of the miners, on their plunger pumps, to keep the former a minimum, and although it cannot be claimed that the calculated duty is a rigidly correct statement, it is fair to assume that these errors in calculation, may in many cases nearly balance each other. The extraordinary lift of many of the mines, ranging in some cases to 1265 feet, and generally exceeding 700 feet, facilitates the pump duty, high lifts being more economical than low ones; the greatest delivery being about 1000 gallons per minute, and the average probably exceeding 300 gallons. The piston load is also heavy, sometimes reaching 18 lbs. per square inch.

Mining engines averaged in this way per year of record, have given returns, as follows (except that of 1855, which is for one month):—

Year.	No. of Engines.	Average Duty.	Average Duty of best Engines.
1838	61	58·	100·2
1839	52	65·4	92·6
1840	54	64·3	97·2
1841	56	65·1	121·3
1842	49	64·0	127·9
1843	36	71·4	114·4
1855	15	68·4	101·3

The figures in the last two columns, being millions of foot-pounds per bushel of coal.

On the supposition of a balance of losses in the pumps, the range

of duty in the last column is 828,000 to 1,142,000 foot-pounds per pound of coal for a bushel of 112 pounds.

In a special trial of an 80-inch engine at Fowey Consols, for  $24\frac{3}{4}$  hours, by the Cornish rule of calculation, and with coal of 94 lbs. per bushel, the duty was 125·095,713 foot-pounds per bushel, or 1,330,800 foot-pounds per pound of coal.

Taylor's 85-inch engine at United Mines, for September 1842, was reported at 107,000,000 foot-pounds per bushel; the engine using 40 lbs. steam and  $\frac{1}{10}$  to  $\frac{1}{12}$  cut-off.

The average duty of these engines, as given by Mr. Wicksteed, in 1859, one for 11 years, and the other for 8 years, for New Castle coal, is 75,230,528 foot-pounds for the former, and 83,875,376 for the latter.

In the experiments on the East London Cornish Engine, with weighed coal, in 1840, the pump duty was in one case 97,146,268 foot-pounds per bushel of 112 lbs., the corresponding cylinder duty being 136,127,408 foot-pounds, and for an evaporation of 8·524 lbs. of water per pound of New Castle coal. Boiler pressure 51·7 lbs. cylinder steam 45·7 lbs. steam jacket loss  $\frac{1}{2}$  per cent. We have then about 12 per cent. steam loss between the boiler and piston, and 28·6 per cent. between the piston and point of water delivery, being 40·6 in all, while the evaporation is 40 per cent. less than the theoretical standard above assumed.

The average duty of two Cornish engines at this Water-works, also cited in 1859, was for New Castle coal, 95,234,885 foot-pounds, as compared with the above average of the mining engines.

It is also shown in 1840 that while the duty at an expansion of 0·397 of the stroke was 78,535,512 at 0·687 it was 108,198,102 or 37 per cent. better, as applied to an experimental standard of 9·493 lbs. evaporation, in calculating the duty.

Taking the experimental duty of 97,146,268 foot-pounds for 112 lbs. coal, the duty per pound is 867,376 foot-pounds. We have then not only the experimental demonstration of a gain of 37 per cent. between two grades of expansion, but an actual result in pump work, independent of all losses by friction and otherwise, between the boiler and point of water delivery, which exceeds the theoretical duty of one pound of coal in the boiler, at atmospheric pressure and under perfect evaporation, as 867,376 to 838,819. The ratio of gain by expansion chiefly explains this singular result. It is proper however to say, that no loss of action is charged to the pump of 9 ft. stroke by 9·168 square feet area, and 108 ft. actual lift, and no addition is made for force-main friction. In a water-works engine of this kind the former probably much exceeds the latter.

It must also be observed that the total engine friction and the loss between the boiler and cylinder are much above the ordinary experimental losses in Cornish engines; 10 per cent. friction, and 5 per cent. steam waste, being much nearer the usual experience, or a total loss in first class mining engines of 60 to 70 per cent. below theoretical duty, in special trials. The 85-inch engine above mentioned, realized 38·7 per cent. in duty.

Experiments on evaporation uniformly show a loss between actual tank measurement and indicator measurement by volumes. In some cases it ranges to 23·5 and 24·3 per cent., as we have observed it; in other cases it has been reported less. This loss combines the ordinary boiler and cylinder wastes by leakage, priming, condensation, radiation, &c., and is therefore in excess always of simple steam waste.

If then the evaporation loss is taken at 30 per cent., the water and steam loss at 15 per cent. and the engine friction at 20 per cent., which are moderate rates, it is easy to see how the actual gain by expansion is absorbed, and equally plain how incompatible any high range of duty is with full steam stroke.

We also learn from these examples, the prominent rank of the single-acting engine in actual pump duty, in special cases and in a large class, as also for very long periods of time.

The experiments at the East London Water-works, on the Boulton and Watt engine gave a duty of 42,847,598 foot-pounds per bushel of 112 lbs., or 382,568 foot-pounds per pound of coal. The expansion was 0·367 of the stroke, boiler steam 17·7 lbs.

A double-acting engine at Wheal Vor, is reported for June, 1841, at 61,966,317 foot-pounds; another of same size (36-inch) at Tin Croft, in the same report gives 36,971,087 foot-pounds.

The double-cylinder engines of the Thames Dilton class, double-acting, are in several cases reported at high ranges of duty.

An experiment on the four Chelsea engines of this class, August, 1857, in which the duty is calculated from the pump contents, and the equivalent head including pump friction, gives 926,400 foot-pounds per pound of coal; the expansion is eight-fold.

Some of the double-acting engines in the United States have been thus reported.

Pittsburgh, 1841. upper service engines 178,050 foot-pounds; lower service engines 170,648 foot-pounds.

Alleghany City, 1841, 171,667 foot-pounds.

Detroit, 1860. No. 2 engine, 341,111 foot-pounds.

Philadelphia, 1858. Spring Garden engines Nos. 1, 2 and 3, 255,000 foot-pounds.

Experiments with the Cincinnati engines, in 1862, to test the economy of a condenser, had the following results, as to this attachment and as to expansion and pressure.

WITHOUT CONDENSER.		
Boiler Steam.	Cut-off.	Duty.
90	$\frac{3}{8}$	350,633 ft.-lbs.
90	$\frac{2}{3}$	405,258 "
110	$\frac{3}{8}$	404,707 "

In the first case, the cylinders were not clothed. In the second this was done, the feed-water heated, and a damper applied to the chim-

ney. In the third case, the feed-water heating arrangement was detached.

WITH CONDENSER.		
Boiler Steam.	Cut-off.	Duty.
90	$\frac{2}{3}$	354,652
90	$\frac{1}{2}$	352,880
90	$\frac{1}{3}$	358,385
80	$\frac{2}{3}$	326,231
40	$\frac{1}{2}$	265,685
115	$\frac{1}{3}$	362,789
90	$\frac{1}{2}$	321,975
110	$\frac{1}{3}$	362,239

The first trial without cylinder clothings, the next three with clothing and feed-heat, and the last four, without the feed-heat. The results showed no advantage in condensing under steam of the ordinary working pressure, and as a running commentary on expansion, give 27 per cent. for a change from  $\frac{2}{3}$  to  $\frac{1}{3}$  cut-off, and of 115 to 40 pounds pressure.

The duty of the "Bull" engines at the 24th Ward Works, Philadelphia, in 1862, was 385,450 foot-pounds by Cornish rule. At Buffalo, by experiment in 1852, the duty was 370,000 foot-pounds.

The duty of the Cornish engine at Philadelphia for 1858, was 465,400 foot-pounds. At Cleveland for 1862, one engine gave 550,000 and the other 490,000 foot-pounds. On special trial in 1856, the Spring Garden engine (Philadelphia) gave 589,053 foot-pounds.

The pump duty of the Belleville Cornish engine (Jersey City), on special test in 1857, was 680,660 foot-pounds.

The combined cylinder engine at Cambridge, which has about three-fold expansion, on special test, without actual measurement of delivery, gave 551,261 foot-pounds.

The Hartford engine on special trial in 1856, gave 591,505 foot-pounds, actual pump duty. The annual duty for 1857, was reported at 592,694 foot-pounds.

The Prospect Hill engine, Brooklyn, which is double-acting, working two pumps from its beam, and connected with a fly-wheel and shaft under special trial in 1862, gave 649,577 foot-pounds for 93 hours trial and 684,042 foot-pounds, for 10 hours of this time.

The duty of the No. 1 engine of Brooklyn, tested in 1860, was 611,114 foot-pounds, and of No. 2, tested in 1862, 606,613 foot-pounds.

It is obvious from these instances, that we have as yet entirely failed to reach either the standard of actual results in the mining engines of the Cornish school, or the results theoretically within reach; and these facts furnish a sufficient comment on the argument presented under each division as to the great need of a more perfect system of design, workmanship, and operation.

If time permitted, it would be a matter of interesting analysis to trace out in the various results above experimentally given, the special

causes which have controlled them, and to show how readily they resolve themselves into an argumentative defence of the prominent laws of action we have presented. We have high steam and expansion vitiated by excessive friction, and light friction vitiated by low steam, improper proportion, and defective expansion; some bad quality or other, constantly counteracting the good ones; pumps badly located, water passages tortuous and contracted, engines overloaded with gearing and frictional resistances or deprived of adequate momentum, and boilers wasting 30, 40, and 50 per cent. of their coal combustion, and a large per centage of their steam. The field of study here is large and of vast consequence; the lines and directions of improvement are plain; the teachings of theory and practice unmistakable.

As a special example in these respects, we may take the Prospect Hill rotative engine, and the Ridgewood engine at Brooklyn.

The former was worked under a boiler pressure of about 45 lbs. steam, with about  $\frac{1}{4}$  th cut-off. Taking one portion of the trial of 11 hours in comparison with another portion of 10 hours, with 149 lbs. coal per hour, a pump load of 28.78 lbs., a cut-off of 0.35, and boiler steam at 22.5, the revolutions were 1233 per hour, while with the same coal, a water load of 28.54 lbs., boiler steam 44.3 lbs., and cut-off 0.145, the revolutions were 1379 or 11.2 per cent. better. Comparing two observations together of two distinct hours, where the expansion in one case was 0.35, and in the other 0.05, the relative duty of the latter was 58 per cent. better than the former. And yet the engine, as a whole, like all others of its class, was defrauded of any high range of duty, by its losses in friction, steam waste, and evaporation.

On the other hand, the Ridgewood engine, which has less than 8 per cent. friction between the piston and pump, and which has never been worked Cornish fashion, and has not now by a number of tons, its proper counterweight, which works with 18 pounds boiler pressure and 8 lbs. cylinder steam, cutting-off at 0.4, obtains its duty of 611,000 foot-pounds, under conditions which are manifestly unfavorable to high results and solely through its perfection of motion. Properly adjusted and operated, there would be no trouble in carrying it up to 1,000,000 foot-pounds duty.

In the latter case, it was proved by a series of gradual improvements in 1859, resulting from increased pressure in the boiler and increased weight on the beam, that the progress towards maximum performance was strictly defined; and the results with the second engine fully confirmed the theory, though vitiated by neglect of its proper development. As an illustration of the effect of increased load, the dotted line of the pump card, noticed at page 299, vol. xlv, is given. This shows greater smoothness of action and less loss in power, in confirmation of the general theory advanced. The results which will be obtained when these engines are worked under proper expansion, cannot fail to confirm the Cornish experience in this respect; an experience which furnishes the engineering world with a forcible argument on the benefits of carefulness in design and simplicity in operation.

(To be Continued.)

*The Economic Construction of Girders.*

From the Lond. Civ. Eng. and Arch. Jour.

The following corrections in the original articles have been sent to us by the author, Robert H. Bow, Esq., Civil Engineer, Edinburgh.  
EDITOR.

*Corrigenda.*

VOL. XLIII.

Page 302, second line above Table II, take out the word "so."

VOL. XLIV.

Page 25, Formula (5), For  $x = \left( \frac{a_1 + c}{a_1 c} \right) \&c.$ , read  $x = c \left( \frac{a_1 + a_1}{a_1 c} \right) \&c.$

Page 26, first line above table, for "at," read "as;" also the same at next formula.

Page 82 line 29 from bottom, for "As the above title," read "As this title."

Page 85, line 6, for "each part made," read "each part of the web made."

Page 153, line 12 from bottom, for " $=0.10297$ ," read " $=0.11297$ ."

Page 154, lines 15 to 19, take out all.

Page 313, line 4, for the word "fully," read "nearly."

Page 316, line 8 from bottom for " $e1$ ," read " $e : 1$ ."

Page 318, line 2 from top, for " $i$ " read "*one inch*."

Page 318, line 10 from top, for " $\frac{1}{s}$ ," read " $\frac{1}{g}$ ."

Page 380, line 6, take out the word "the."

Page 380, line 11 from bottom, for " $c$ " at head of column in table, read " $c$ ."

Page 382, line 28, for "formulæ," read "formula."

VOL. XLV.

The foot note on page 16 and the first on page 20 should be transposed.  
ROBERT H. BOW.

## MECHANICS, PHYSICS, AND CHEMISTRY.

*Results of an Experimental Inquiry into the Comparative Tensile Strength and other Properties of various kinds of Wrought Iron and Steel.* By MR. DAVID KIRKALDY.

From the *Mechanics Magazine*, December, 1862.

Mr. Kirkaldy exhibited several cases of the fractured specimens upon which his experiments were made; and, by way of introduction to the discussion, there were read from his Treatise the following conclusions arrived at by Mr. Kirkaldy in the course of his inquiry:—

1. The breaking strain does *not* indicate the quality as hitherto assumed.

2. A *high* breaking strain may be due to the iron being of superior

quality, dense, fine, and moderately soft, or simply to its being very hard and unyielding.

3. A *low* breaking strain may be due to looseness and coarseness in the texture, or to extreme softness, although accompanied by very close and fine quality.

4. The contraction of area at fracture, previously overlooked, forms an essential element in estimating the quality of specimens.

5. The respective merits of various specimens can be correctly ascertained by comparing the breaking strain *jointly* with the contraction of area.

6. Inferior qualities show a much greater *variation* in the breaking strain than the superior.

7. Greater differences exist between small and large bars in coarse than in fine varieties.

8. The prevailing opinion of a rough bar being stronger than a turned one is erroneous.

9. Rolled bars are slightly hardened by being forged down.

10. The breaking strain and contraction of area of iron plates are greater in the direction in which they are rolled than in a transverse direction.

11. A very slight difference exists between specimens from the centre and specimens from the outside of crank-shafts.

12. The breaking strain and contraction of area are greater in those specimens cut lengthways out of crank-shafts than in those cut crossways.

13. The breaking strain of steel, when taken alone, gives no clue to the real qualities of various kinds of that metal.

14. The contraction of area at fracture of specimens of steel must be ascertained as well as those of iron.

15. The breaking strain, *jointly* with the contraction of area, affords the means of comparing the peculiarities in various lots of specimens.

16. Some descriptions of steel are found to be very hard, and consequently, suitable for some purposes; whilst others are extremely soft, and equally suitable for other uses.

17. The breaking strain and contraction of area of *puddled* steel plates as in iron plates, are greater in the direction in which they are rolled; whereas in *cast* steel they are less.

18. Iron, when fractured suddenly, presents invariably a crystalline appearance; when fractured slowly, its appearance is invariably fibrous.

19. The appearance may be changed from fibrous to crystalline by merely altering the shape of the specimen so as to render it more liable to snap.

20. The appearance may be changed by varying the treatment so as to render the iron harder and more liable to snap.

21. The appearance may be changed by applying the strain so suddenly as to render the specimen more liable to snap, from having less time to stretch.

22. Iron is less liable to snap the more it is worked and rolled.

23. The "skin" or outer part of the iron is somewhat harder than the inner part, as shown by appearance of fracture in rough and turned bars.

24. The mixed character of the scrap iron used in large forgings is proved by the singularly varied appearance of the fractures of specimens cut out of crank-shafts.

25. The texture of various kinds of wrought iron is beautifully developed by immersion in dilute hydrochloric acid, which, acting on the surrounding impurities, exposes the metallic portion alone for examination.

26. In the fibrous fractures the threads are drawn out, and are viewed externally, whilst in the crystalline fractures the threads are snapped across in clusters, and are viewed internally or sectionally. In the latter cases the fracture of the specimen is always at right angles to the length; in the former it is more or less irregular.

27. Steel invariably presents, when fractured slowly, a silky fibrous appearance; when fractured suddenly the appearance is invariably granular, in which case also the fracture is always at right angles to the length; when the fracture is fibrous, the angle diverges, always more or less from 90 degrees.

28. The granular appearance presented by steel suddenly fractured is nearly free of lustre, and unlike the brilliant crystalline appearance of iron suddenly fractured; the two combined in the same specimen are shown in iron bolts partly converted into steel.

29. Steel which previously broke with a silky fibrous appearance is changed into granular by being hardened.

30. The little additional time required in testing those specimens, whose rate of elongation was noted, had no injurious effect in lessening the amount of breaking strain, as imagined by some.

31. The rate of elongation varies, not only extremely in different qualities, but also to a considerable extent in specimens of the same brand.

32. The specimens were generally found to stretch equally throughout their length until close upon rupture, when they, more or less, suddenly drew out, usually at one part only, sometimes at two, and, in a few exceptional cases, at three different places.

33. The ratio of ultimate elongation may be greater in short than in long bars in some description of iron, whilst in others the ratio is not effected by difference in the length.

34. The lateral dimensions of specimens form an important element in comparing either the rate of, or the ultimate, elongations—a circumstance which has been hitherto overlooked.

35. Steel is reduced in strength by being hardened in water, while the strength is vastly increased by its being hardened in oil.

36. The more highly steel is heated (without, of course, running the risk of being burned) the greater is the increase of strength, on its being plunged into oil.

37. In a highly converted or hard steel, the increase in strength and in hardness is greater than in a less converted or soft steel.



38. Heated steel, by being plunged into oil, instead of water, is not only considerably *hardened*, but *toughened* by the treatment.

39. Steel plates hardened in oil, and joined together with rivets, are fully equal in strength to an unjointed soft plate, or the loss of strength by riveting is more than counterbalanced by the increase in strength by hardening in oil.

40. Steel rivets, fully larger in diameter than those used in riveting iron plates of the same thickness; being found to be greatly too small for riveting steel plates, the probability is suggested that the proper proportion for iron rivets is not, as generally assumed, a diameter equal to the thickness of the two plates to be joined.

41. The shearing strain of steel rivets is found to be about a fourth less than the tensile strain.

42. Iron bolts, case-hardened, bore a less breaking strain than when wholly iron, owing to the superior tenacity of the small proportion of steel being more than counterbalanced by the greater ductility of the remaining portion of iron.

43. Iron highly heated, and suddenly cooled in water, is hardened, and the breaking strain, when gradually applied, increased, but, at the same time, it is rendered more liable to snap.

44. Iron, like steel, is softened, and the breaking strain reduced, by being heated and allowed to cool slowly.

45. Iron, subjected to the cold-rolling process, has its breaking strain greatly increased by being made extremely hard, and not by being "consolidated," as previously supposed.

46. Specimens cut out of a crank-shaft are improved by additional hammering.

47. The galvanizing or tinning, of iron plates, produces no sensible effects on plates of the thickness experimented on. The results, however, may be different should the plates be extremely thin.

48. The breaking strain is materially affected by the shape of the specimen. Thus the amount borne was much less when the diameter was uniform for some inches of the length than when confined to a small portion—a peculiarity previously unascertained, and not even suspected.

49. It is necessary to know correctly the exact conditions under which any tests are made, before we can equitably compare results obtained from different quarters.

50. The startling discrepancy between experiments made at the Royal Arsenal, and by the writer, is due to the difference in the shape of the respective specimens, and not in the difference in the two testing machines.

51. In screwed bolts, the breaking strain is found to be greater when old dies are used in their formation than when the dies are new, owing to the iron becoming harder by the greater pressure required in forming the screw thread when the dies are old and blunt, than when new and sharp.

52. The strength of screw-bolts is found to be in proportion to

their relative areas, there being only a slight difference in favor of the smaller, compared with the larger sizes, instead of the very material difference previously imagined.

53. Screwed bolts are not necessarily injured, although strained nearly to their breaking point.

54. A great variation consists in the strength of iron bars which have been cut and welded; whilst some bear almost as much as the uncut bar, the strength of others is reduced fully a third.

55. The welding of steel bars, owing to their being so easily burned by slightly overheating, is a difficult and uncertain operation.

56. Iron is injured by being brought to a white or welding heat, if not at the same time hammered or rolled.

57. The breaking strain is considerably less when the strain is applied suddenly, instead of gradually, though some have imagined the reverse is the case.

58. The contraction of area is also less when the strain is suddenly applied.

59. The breaking strain is reduced when the iron is frozen; with the strain gradually applied, the difference between a frozen and unfrozen bolt is lessened, as the iron is warmed by the drawing out of the specimen.

60. The amount of heat developed is considerable when the specimen is suddenly stretched, as shown in the formation of vapor from the melting of the layer of ice in one of the specimens, and also by the surface of others assuming tints of various shades of blue and orange, not only in steel, but also, although in a less marked degree, in iron.

61. The specific gravity is found generally to indicate pretty correctly the quality of specimens.

62. The density of iron is *decreased* by the process of wire-drawing, and by the similar process of cold-rolling, instead of *increased*, as previously imagined.

63. The density in some descriptions of iron is also decreased by additional hot-rolling in the ordinary way; in others the density is very slightly increased.

64. The density of iron is decreased by being drawn out under a tensile strain, instead of increased, as believed by some.

65. The most highly converted steel does not, as some may suppose, possess the greatest density.

66. In cast steel the density is much greater than in puddled steel, which is even less than in some of the superior descriptions of wrought iron.

The breaking strain per square inch of wrought iron is generally stated to be about 25 tons for bars and 20 tons for plates. This corresponds very nearly with the results of the writer's experiments, of which the following table presents a condensed summary:—

	lbs. Highest.	lbs. Lowest.	lbs. Mean.	Tons.
188 bars rolled,	68,848	44,584	57,555	= 25 $\frac{1}{4}$
72 Angle iron, &c.,	63,715	37,909	51,729	= 24 $\frac{1}{2}$
167 Plates lengthways,	62,544	37,474	50,737	} = 24 $\frac{1}{4}$
160 Plates crossways,	60,756	32,450	46,171	

Although the *breaking* strain is generally assumed to be about 25 tons for bars and 20 tons for plates, very great difference of opinion exists as to the amount of *working* strain, or the load which can with safety be applied in actual practice. The latter is variously stated at from a third to a tenth. It will be observed that whilst much discussion has arisen as to the amount of working strain, or the ratio the load should bear to the breaking strain, the important circumstance of the *quality* of the iron, as influencing the working strain, or the ratio the load should bear to the breaking strain, the important circumstance of the *quality* of the iron, as influencing the working strain, has been overlooked. The Board of Trade limits the strain to five tons, or 11,200 lbs. per square inch.

It must be abundantly evident, from the facts which have been produced, that the breaking strain, when taken alone, gives a false impression of, instead of indicating, the real quality of the iron, as the experiments which have been instituted reveal the somewhat startling fact, that frequently the inferior kinds of iron actually yield a higher result than the superior. The reason of this difference was shown to be due to the fact, that whilst the one quality retained its original area, only very slightly decreased by the strain, the other was reduced to less than one-half. Now, surely this variation, hitherto unaccountably completely overlooked, is of importance, as indicating the relative hardness or softness of the material, and thus, it is submitted, forms an essential element in considering the safe load that can be practically applied in various structures. It must be borne in mind that although the softness of the material has the effect of lessening the amount of the *breaking* strain, it has the very opposite effect as regards the *working* strain. This holds good for two reasons: first, the softer the iron the less liable it is to snap: and, second, fine or soft iron, being more uniform in quality, can be more depended upon in practice. Hence the load which this description of iron can sustain with safety, may approach much more nearly the limit of its breaking strain than can be attempted with the harder or coarser sorts, where a great margin must necessarily be left.

Special attention is now solicited to the practical use that may be made of the new mode of comparison introduced by the writer, viz: *the breaking strain per square inch of the FRACTURED area of the specimen, instead of the breaking strain per square inch of the ORIGINAL area.*

As a necessary corollary to what he has just endeavored to establish, the writer now submits, in addition, that the *working* strain should be in proportion to the breaking strain per square inch of fractured area, and not to the breaking strain per square inch of the original area, as heretofore. He does not presume to say what that ratio

should be, but he fully maintains that some kinds of iron experimented on by him will sustain with safety more than double the load that others can suspend, especially in circumstances where the load is unsteady, and the structure exposed to concussions, as in a ship, or to vibratory action as in a railway bridge.

The writer has not attempted to explain the cause of the mysterious change produced on steel by heating it and plunging it into water, or the no less singular result effected by plunging it, when heated, into oil. Neither has he tried to account for the mysterious change produced by subjecting iron to the processes of cold-rolling or wire-drawing. The explanation offered by some, of this difficult question, that the iron or steel are *condensed* by the processes to which they are subjected, is completely contradicted by fact, the metal being actually *expanded*. The aim of the writer being strictly to ascertain facts, and state the conclusions which he considers to be fairly deducible from them, he has not felt himself warranted in attempting to speculate on a subject respecting which so little is yet known.

In conclusion, the writer ventures only to express a hope that the experiments, on which he has been so long and unremittingly engaged, may not prove wholly unserviceable to practical science and the world at large. The importance of possessing a thorough knowledge of the capabilities and strength of substances on which the lives and property of so many human beings depend, no one will attempt to deny. The only excuse, if, indeed, excuse it can be called, for employing an inferior description of material in the rearing of structures on the stability of which such momentous issues are involved, is ignorance or misapprehension of its proper quality. The writer has endeavored, by a plain statement of facts, to furnish some information on a subject which seems, until now, to have been denied the attention which its paramount importance demands. Were this question fairly taken up and considered, some security might be afforded against the repetition in future, of disasters occasioned by its being so often practically ignored. The necessity of using nothing but the very best description of metal, where human life or valuable property is at stake, may, he trusts, come soon to be more generally recognised than it is at present. And an increased demand for the finer varieties may conduce to a generous emulation amongst the manufacturers to improve still further the quality of their productions. Should his labors tend in any way, even the smallest degree, to diminish the annual sacrifice of life and property occasioned by faulty material and workmanship, he will feel the satisfaction that, they have at least, not been entirely in vain.

Mr. Kirkaldy exhibited 490 selected specimens, which were contained in five cases, namely:—

IN CASE I.

- 9 iron bars, showing elongation and lateral contraction.
- 1 iron plate, do.
- 1 steel plate, do.

IN CASE II.

- 42 steel bars, showing fractures and contraction of area.
- 105 iron bars, do.

## IN CASE III.

- 36 steel plates, showing fractures and contraction of bars.
- 60 iron plates, do.
- 24 angle iron, &c., do.

## IN CASE IV.

- 36 iron bars, showing fractures and effects of difference of shape.
- 40 iron bars, showing fractures and effects of difference of treatment.
- 12 steel bars, do.
- 10 iron plates, do.
- 15 iron bars, showing fractures and effects of strains suddenly and gradually applied.

## IN CASE V.

- 46 iron bars, showing fractures of screwed bolts.
- 12 iron bars, showing fractures of welded joints.
- 2 steel bars, do.
- 26 iron bars, showing texture as developed by acid.
- 8 iron plates, do.
- 1 iron plate, with surface cold-rolled.
- 4 iron bars, with surface cold-rolled.

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For the Journal of the Franklin Institute.

*Fluid Resistance.* By JOHN A. GRIER.

In this brief article I will not attempt to investigate the abstruse question of fluid resistance as a whole, but simply desire to attract attention to a single phase of this most interesting subject.

If I am able to make my views distinctly understood, concerning the front resistance which a vertical plane meets with and has to overcome, in passing through a fluid in a direction perpendicular to this plane, I will have accomplished my design.

The amount of resistance for any one velocity is not desired,—but simply the relative resistance at different velocities.

The theoretical question is this: Suppose we have a vertical plane totally submerged, and moving through a fluid in a direction perpendicular to this plane but at variable velocities, how will the resistance and the power necessary to overcome this resistance vary, in order to move the plane with these variable velocities?

In order to be more distinctly understood, I will explain that I understand *the resistance overcome* to be a true criterion of the power expended, in whatever way this power may be developed.

The well known law always given and never disputed is: That the resistance varies as the square of the velocity.

But this law is differently understood, some understanding it to mean the resistance for a *certain space* moved through, and others for a *certain time*.

So to avoid this ambiguity of expression that is so easily mistaken, I would lay down my view of this law more explicitly, thus: The front resistance that a plane moving through a fluid in a direction perpendicular to this plane will meet with, during a *certain time*, will vary as the square of the velocity. And that the front resistance which this same plane will meet with, while passing through a *certain space*, will vary simply as the velocity.

This view of the question is taken by Olmstead and Arnott, while a different view is more generally accepted by men eminent for their practical and theoretical abilities in engineering, I will simply cite two instances, Bourne, the great English author on steam engineering, and J. Scott Russel, the builder of the *Great Eastern*.

Olmstead and Arnott say, that the power necessary to be expended to overcome the front resistance of a steamer for a *certain time* varies as the square of the velocity, but Olmstead and Arnott were not practical men perhaps,—so Bourne, Russel, and hundreds of others, who are the *practical builders* of our steamers, say that the power necessary to overcome this theoretical front resistance varies as the cube of the velocity.

And engineers of all kinds, who try to add just one knot more to the speed of their vessels, when they have already attained a high speed, know that the fuel expended in obtaining this extra knot is an increase of a very large per centage on the normal quantity of coal consumed.

But that to increase the speed of a vessel from half her average speed to her average speed, would increase the consumption of coal as much as eight-fold as Bourne and the believers of the cube theory teach, is something with which my own experience for several years does not agree.

So first we will endeavor to settle the question practically in this manner. If there is to be an increase of speed of a steamer beyond her ordinary fast speed, the expenditure of power or the expenditure of fuel is increased in a greatly increasing ratio, sometimes even exceeding the cube of the velocity.

This can be accounted for by the increased inefficiency of the propelling instrument (whether it be a screw or a side-wheel), moved at very high velocities, and to the forced and incomplete combustion of the fuel. There are other causes, but these two are the principal ones.

When the vessel's speed is increased from half her average speed to her average speed, these two causes affect the results but very little; hence we may not wonder if by increasing the quantity of fuel per hour four or five-fold, it does increase the speed from half the average speed to the average speed. It is an experiment I have frequently tried with these results.

But let the practical question be settled as it may, for the present the theoretical front resistance is what we wish to consider.

The reasoning on this subject is this: If, during a *certain time*, we double the velocity of the plane we double the number of particles struck during this *certain time*, and also strike each one with a double velocity.

As the resistance varies as the number of particles struck, multiplied by the velocity with which they are struck, we have this four-fold resistance for this *certain time* accounted for. Or we have a reason for this law; that the resistance to our plane for a *certain time* will vary as the square of the velocity.

If the resistance for a *certain time* varies as the square of the velo-

city, the power which will be necessary to be expended during this time to overcome this resistance, will also vary as the square of the velocity.

And from this it is also deduced, that the resistance for our plane moving through a *certain space* as well as the power that is necessary to be expended in overcoming this resistance varies as the velocity simply.

Hence, practically speaking, *if the front resistance of a steamer was alone to be considered, to double the speed while going from one port to another, would require an engine of the ability to develop a quadrupled quantity of power during a certain time, but consuming only a double quantity of fuel.*

The *quadrupled* increase in the engine's capabilities to develop power would be required, in order to develop this *double* quantity of power required in one-half the time that the engines would have to develop it, if the steamer was moving at the slower speed.

Hence, to double the speed of a steamer, if the front resistance was the only resistance to be overcome, and if there was no direct loss of power on account of the increased velocity of the engines or forced combustion of the fuel, then the quantity of fuel consumed to drive the steamer at a double speed for a *certain space* would have to be increased two-fold only, and this doubled quantity of fuel would develop from our *four-fold increased engine only a double quantity of power.*

If this four-fold increased engine in our fast steamer was to develop power for the same *length of time*, as the single engine in the slow steamer, then the quantity of fuel consumed, or power developed, would also be increased four-fold.

These exact results in practical steamship propulsion, of course, could not be expected, but because they are not realized we are not obliged to arrive at erroneous conclusions on the whole subject.

Although the angular entrance of an ordinary steamer decreases the front resistance to a very great extent, when compared with the resistance the bow would meet with if rectangular, yet the principle holds good, that the particles of water must be driven from a bow of a certain form, with velocities varying as the speed of the steamer.

Now, I will endeavor to explain the deductions from experiments on which the advocates for the cube theory base their theory.

I will endeavor to prove most conclusively why it is that this erroneous theory receives so general acceptance.

By direct experiment it has been shown, that if a weight be attached to a cord running over a pulley, and then made fast to a body floating in a fluid, so that the descending weight will pull the floating body through the fluid with a certain velocity, then, to double the velocity of this floating body, the weight must be increased *four times*.

And as at this double velocity the large weight would have to move through twice the *space* to overcome the resistance of the floating body for the *same length of time*, it is estimated that the power developed by the force of gravity acting on this descending weight, in order to double the velocity of the floating body *for a certain time* varies as 8 : 1.

Thus, weight 1 multiplied by space 1 is said to represent the mechanical effect of the small weight; while weight 4 multiplied by space 2 is said to represent the mechanical effect of the large weight.

A most accurate and careful set of experiments were made by the French Academicians D'Alembert, Bossuet, and Condorcet, in 1787, and the results of these experiments seem to have been so conclusive as to have been received without doubt.

The height through which the weight fell, multiplied by the weight, varied nearly as the cube of the velocities with which they drew the float through the fluid.

However, these experiments are not the only foundation for the cube theory, as Bourne, in discussing this subject, asserts that *Newton is wrong* in thinking that if a body is put in motion by an expenditure of a certain definite quota of power, then to put this same body in motion again with *double* its former velocity will require but a *double* expenditure of power.

Bourne's theory is, that if a body is put in motion by a certain expenditure of power, then it would require a *quadrupled* expenditure of power to give a similar body a *double* velocity. This theory he thinks he proves conclusively by the laws of gravity, and if his views on that subject are not erroneous, he undoubtedly proves this theory on momentum as correct, as well as his cube theory or fluid resistance.

In an article on momentum, published in the January number of this *Journal*, I have asserted:—"That the generally received criterion of 'work done,' or 'mechanical effect,' 'power expended,' or 'resistance overcome,' being the space through which a body is moved, was erroneous."

*The height through which a body is raised multiplied into its weight is a gauge for "work done" or "mechanical effect," more universally used than a two foot-rule is for measuring dimensions.*

If an incorrect gauge is used, no wonder that there are some striking discrepancies in conclusions.

If we can determine the *actual resistance overcome*, when a body is moved through a space during a certain time, that, and that only, will be a true, unvarying criterion for mechanical effect.

It is well determined, both from theory and experiment, that if an initial velocity be given to a body in an upward direction, sufficiently great to raise it 16 feet during one second, it will overcome the uniform resistance of gravity for one second. Then to give a similar body double this initial velocity, it will raise the body not 32 feet, but 64 feet, and be two seconds in doing this work, or it will overcome the uniform resistance of gravity for two seconds.

Hence, although the spaces through which these bodies are raised vary as 1:4, the resistance of the force of gravity overcome, or the power expended in overcoming this resistance of the force of gravity varies as 1:2.

No example can be more simple or more striking. If it fails to convince, reading the remainder of this article will, I fear, be time lost to the reader.



It is on this *false* criterion of mechanical effect—"height multiplied into space," that Bourne defiantly plants his flag as an advocate for the truth of the cube theory.

This false criterion receives universal approbation from all writers on mechanics. It is taught in all our books, and from the desk of every professor of natural philosophy in our schools.

If this is not sufficient evidence to rob it of even a shadow of error, then we may have the temerity to boldly question its correctness. My "*ipse dixit*" is not worth the paper on which it is written,—and perhaps it will be said my reasoning is on a par with it in value, but if my reasoning on this subject will bear the test of examination, then our books on mechanical science will stand a slight overhauling to advantage,—and our philosophical professors may re-write some of their lectures. For several years I have particularly noticed the discrepancy on this subject, and have anxiously and patiently waited for some master-mind to unravel the mystery. Page after page has been written, but no one appears to have drawn the curtain to one side.

If success should crown my effort, I shall be sufficiently repaid for my seemingly independent course of thinking, and thus trifling with the opinions of high authorities.

The criterion of *resistance overcome* is the pivot on which the whole subject beautifully turns.

If in any of the experiments recorded where the velocity varies as 1:2 we multiply the height through which the weights descended for a *certain time*, by the weights, while they were overcoming the resistance of the floating body,—then, the mechanical effect of the force of gravity developing power—*does vary as the cube of the velocity*.

But, if we multiply the times during which the uniform force of gravity was developing power, (which times being equal,) into the weights, which varied as 1:4, then the mechanical effect which the uniform force of gravity developed would vary as 1:4, *or as the square of the velocity simply*.

This fact is elegantly illustrated in the experiments made by the French Academicians as recorded in their Memoirs.

They may not have observed it particularly,—as this series of experiments were introduced to prove the cube theory beyond a doubt, and are referred to for such proof to this day.

If it is true that the force of gravity does develop four times as much power when it draws a body through a space of 64 feet in two seconds, that it does in drawing it through 16 feet in the first of these two seconds, then the cube theory is correct.

It is evident that experiments and deductions made with a false criterion of mechanical effect are vitiated in their conclusions.

With this understanding, several years ago, I made an experiment on fluid resistance with the following results:

The experiment was a rude one however, the details, of which I have lost, and with my present facilities, I cannot repeat it.

Two light metallic planes were so weighted as to keep the top side uppermost, and of a specific gravity but little greater than the water,

and so filled in on the under side as to diminish the resistance of the water dragging after them as much as possible. So that when these planes were drawn up by cords from a depth of water of about twenty feet, the great portion of the resistance was front resistance.

By a crank and axle having two diameters varying as 1:2, a coincident motion was obtained for each, but with velocities varying as 1:2. A common spring balance was secured on the cord between the surface of the water and the axle.

This spring balance self-registered the maximum strain on each cord.

This strain on the cords as registered by their respective balances varied nearly as 1:2,—and not as 1:4.

To me it seemed to prove conclusively that the resistance for these planes, while moving during a *certain time*, varied as the square of the velocity,—and for a *certain space* as the velocity simply.

Hence the power required to overcome the resistance for a *certain time* would vary as the square of the velocity, and for a *certain space* as the velocity simply.

The practical bearing of this subject on the *grand* question of steamship resistance and propulsion, is very important, to say nothing of its influence on other great engineering questions.

The settling of it beyond dispute is a subject well worthy of the attention of those whose authority on such subjects could be received with confidence.

My authority, I know, is worthless,—my views on mechanics are bounded by narrow limits, and my attainments are very moderate; therefore I should deeply regret leading any one astray,—if my firm convictions on this subject are erroneous.

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### *Association for the Prevention of Steam Boiler Explosions, Manchester.*

From the Journal of the Society of Arts, No.517.

The engineer's monthly report, made Tuesday, September 30th, 1862, states as follows:—

“I am happy to be able again to report that no explosion has happened during the past month to any boiler under the inspection of this Association, neither has the occurrence of any in other quarters come to my knowledge.

“During the past month there have been examined 263 engines and 451 boilers. Of the latter, 15 have been examined specially, 6 internally, 72 thoroughly, and 358 externally; in addition to which, 4 of these boilers have been tested by hydraulic pressure. The following defects have been found in the boilers examined:—Fracture 8 (1 dangerous); corrosion, 49 (8 dangerous); safety-valves out of order, 3; water gauges ditto, 14; pressure gauges ditto, 4; feed apparatus ditto, 3; blow-off cocks ditto, 16 (1 dangerous); fusible plugs ditto, 5; deficiency of water, 1; blistered plates, 3 (1 dangerous); total, 106 (11 dangerous). Boilers without glass water gauges, 5; without blow-off cocks, 17; without back pressure valves, 25.

“Two boilers have recently been met with, neither of which was fitted with its own separate safety-valve, but both were dependent on a single one placed upon the steam-pipe, the communication between which and each boiler was conditional on its junction-valve being open, so that had the attendant at any time inadvertently left this valve screwed down—on getting up steam, for instance, on a change of boilers—the whole steam pressure must have been bottled up without chance of escape.

“**FEED BACK-PRESSURE VALVES.**—Some of our members do not appear to be fully aware of the importance of fixing a feed-back pressure valve to each of their boilers, and therefore the following instance, lately met with, of the inconvenience arising from the want of them, may be given.

“Four boilers, set side by side, and connected together, were working under their ordinary circumstances, when one of them vomited its water through the feed-pipe into the adjoining one, draining itself and over-charging the other. The danger of this, if not immediately detected, with a fire in active operation, will at once be seen. It is, however, by no means an uncommon occurrence where back-pressure valves are omitted, especially where any thickening matter exists in the water, which tends to lift it and cause priming, under which circumstances the water has been found to rush backwards and forwards alternately, between boilers working in connexion. The back-pressure valve prevents this: the water from the feed-pump operating underneath and raising it, while the pressure from the boiler operates on the top and closes it. Necessary as these valves are to the safety of boilers when working in a series, they should not be neglected in the case of those working singly, not only when fed by a pump, but also when fed direct from the water-works main: in the first case, in order that the pump-valves may be accessible when steam is up, and in the second, that the reflux of hot water from the boiler may be prevented, either on the bursting of the pipe or other cause. These valves should be placed immediately upon the shell of the boiler, and not at a distance from it, as is sometimes the case, since scalding might ensue should any joints break in the intervening length of pipe, while repair could not be effected without letting the pressure down. For the same reason the feed-stop valve should not be interposed, which it too frequently is, between the back-pressure valve and the boiler, since a disarrangement of the stop-valve may entail an entire stoppage, which, had the feed back-pressure valve been placed immediately upon the shell, could easily be rectified with steam up.

“In the construction of this valve care should be taken to limit its rise, for want of which simple precaution some of them have proved to be entirely useless, the water passing freely from one boiler to the other, as if the valve was not there. Its most convenient position is at the front end plate of the boiler, nearly on a level with the furnace crown. Its beat can then be heard at every stroke of the engine, and if a screwed spindle be added, so as to convert it into a

combined feed-stop and back-pressure valve, which is the best arrangement, then the feed can be regulated without leaving the furnaces.

“**BLOW-OUT APPARATUS.**—A case of scalding has lately occurred in consequence of the failure of the blow-out apparatus of a boiler which was, however, not under the inspection of this Association.

“The manner in which blow-out taps are often strained with long levers in opening and closing, renders it a matter of surprise that fracture does not more frequently occur, and many have such inefficient arrangements for carrying off the waste water, that it beats back with so much violence on the taps being opened, that their use is quite dangerous. Enginemen are in this way but too frequently scalded severely, and our own Inspectors sometimes meet with narrow escapes. Some taps are so inconveniently placed that the nut at the bottom of the plug is quite inaccessible, and thus becomes neglected, in consequence of which several cases have occurred of the plug being shot out by the force of the steam on being opened. Taps fitted with glands are safer as well as more convenient; they should, however, be made entirely of brass in the shell as well as in the plug, and be fitted with a suitable waste-pipe. Those made of cast iron in the shell and brass in the plug, are generally found to be inconvenient, and sometimes dangerous, on account of the unequal expansion of the two metals, from which it is frequently impossible to close them, when the boiler becomes robbed of its water, and the fires have to be drawn to prevent injury to the furnaces.

“The case in question, however, was somewhat peculiar, and the fracture did not arise from either of the above causes. The blow-out tap was attached to the boiler by a cast-iron elbow-pipe, and this pipe broke short off without warning, while the boiler was at its regular work and the blow-out tap not being touched.

“The cause of this appeared to be as follows:—Boilers, as has been previously stated in these reports, are too frequently considered to be in a state of rest when once set upon their brickwork bed; whereas, from the constant changes of temperature, and the consequent contraction and expansion that take place not only in the boiler itself, but also in the brickwork, the whole is in a continual state of movement. It appears most probable that this action had, in process of time, induced a slight settlement of the boiler, and thus that a strain was brought upon the cast-iron elbow-pipe, which being bound by the brickwork, consequently gave way. A torrent of hot water naturally ensued, which, unable to escape at the usual outlet, found its way into an adjoining building, where it partially flooded one of the floors, and two or three persons became scalded in consequence.

“**PREVENTION OF INCRUSTATION.**—It may be stated in brief that the scum-pipes for surface blowing out, which have been recommended from time to time, for the prevention of incrustation in boilers, have now been adopted by several of the members, and have, for some time since, been in very successful operation. An early opportunity will shortly be taken of making more detailed reference to this sub-

ject; but, in the meantime, it may be stated that a drawing of the arrangement adopted lies at the office for the inspection of the members, and that full particulars, both of the details of construction and results of working, will be given on application.

“HINTS TO MEMBERS ON LAYING DOWN NEW BOILERS.—There is one branch of the service which this Association affords, which the members do not avail themselves of as fully as they might—namely, that of consulting the records at the office before laying down new boilers or making alterations. Full particulars are kept, not only of the construction of the boilers under inspection, but also of the results of their working; and a consultation of these would frequently save unnecessary outlay, prevent failures of one being repeated by others, and place at the command of each member the experience acquired by the inspection of the whole number of boilers under the charge of the Association.”

For the Journal of the Franklin Institute.

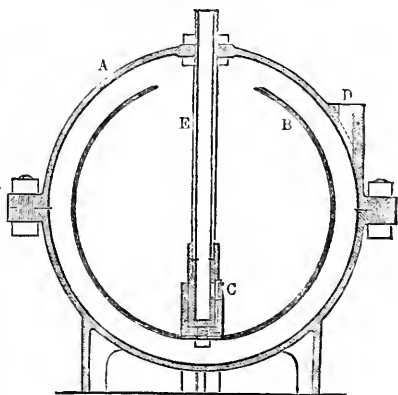
*Furman's Steam Engine Trap.*

It is well known that in boilers with large fire surface and but little steam room, heat is transmitted with great rapidity, causing particles of water to be carried over with the steam into the engine, when running with an open throttle; tubular boilers are known to foam more than others, especially those having vertical tubes.

The damaging effects produced by this water of primage, in addition to the natural condensation of the steam-pipe, side-pipe, steam-chest, &c., is obvious. All boilers foam when they contain a mixture of fresh and salt water, and intelligent engineers will not hesitate to avail themselves of a method to separate water from steam, whenever they can be assured that a suitable instrument has been made to accomplish this result.

The invention of George W. Furman, of New York, is claimed to be the only instrument that has as yet been brought forward that will successfully relieve an engine of the water of condensation and primage. Of this I propose to treat, and herewith annex a sectional drawing of it that will enable the reader to understand its construction and manner of operation:

SECTIONAL VIEW OF TRAP.



A, the outside shell; B, the globe or float; C, a slide valve on the stem; D, the passage through which the water enters the trap; and E, the stem through which it is passed off.

When the trap is first set, there is water enough poured into the outside shell A, to float globe B, and close valve C, which will remain

closed, preventing the passing off of either steam or water until the latter has filled the globe and sunk it, when valve c opens, and the pressure of steam forces the water through pipe E. So soon as the water has passed out of globe B, it will rise and valve c close, preventing the passage of steam as before.

The advantages claimed for the use of this instrument attached to an engine are:—

1. *A Decrease of Wear in Packing, Joints, and Springs.*—It is a fact well known that steam will not rust iron, on the contrary, that marks of paint on that metal have been preserved for years where dry steam has been used, but hot water does, and also decomposes rubber, now extensively used for packing, and will pass through openings where steam will not. It is admitted that packing used with dry steam will last much longer than when water is worked through the engine.

2. *An Economy in Lubrication.*—The purpose of lubricating a steam cylinder is to form a polished coating or burnish on its inner surface, that will fill up the irregularities of the metal. This can be accomplished in no better manner than by the rubbing of similar metals together, and would have the desired result if such surface were allowed to remain. With the use of dry steam this would ensue, but the passage of hot water through the cylinder washes off this coating, leaving the interstices to be filled up with particles of water. The evil effects produced by the adulterated substances known as lubricators, may be seen on many engines; the result of their use being to rot the iron leaving it full of small holes, like honeycomb.

3. *A more thorough Condensation with less Injection Water.*—Dry steam passing from the cylinder to the condenser, requires a certain amount of cold water to reduce its temperature to  $100^{\circ}$ , which is near the average heat of water discharging into the hot-well. If, then, in addition to this steam, there be an increased amount of prime water, or that of condensation at  $212^{\circ}$ , carried into the condenser, it is evident that a larger quantity of cold water will be required to reduce the whole to the required temperature, in which case more work is demanded of the air-pump, and thus power is lost.

4. *No need of Blowing through an Engine to Warm it.*—This point is easily dispensed with, as the work is always done by the trap, which is at all times in operation, whether the engine is moving or standing still; consequently, when there is enough steam in the boiler, the engineer can at once start the engine. When the discharge-pipe is not carried above the connexion with the engine, the weight of the water alone will work the instrument without the aid of steam.

5. *The Engine will not heat while lying still.*—Engines become hot while not in motion, in consequence of the condensed steam passing from the steam-chest into the condenser. That this is effectually prevented by the attachment of the trap, is proven by the fact that the steamer *Flushing*, while in the service of the Government, lay at anchor seven consecutive days, without “turning over” her engines.

The report of the engineer of this vessel is annexed, that this point may not be disputed.

Few engineers fully realize the quantity of water that passes through their engines when their boilers foam, and when the amount is shown them after it has been carried through this instrument, the majority of them have claimed that the greater portion of it is condensed by the instrument itself.

To dispose of this question, in a measure, the reader's attention is asked to the subjoined extract from an official report to the Secretary of the Navy, by B. F. Garvin, Esq., Chief Engineer of the Brooklyn Navy Yard, under date of December 16, 1862:—

"At the end of about two hours, no more water made its appearance. About two gallons of water came from the trap at first, but after half to three-quarters of an hour, it ceased running entirely. I consider the boat was well adapted for the purpose, having the engine at one end and the boiler at the other, necessitating a long steam-pipe, which presented a large surface for condensation."

That the reader may fully understand the merits of the extract just quoted, it is stated that a ferry-boat, plying upon the East River, between New York and Brooklyn, was "laid up" at half-past six o'clock, P. M., and precisely one hour after, Mr. Garvin commenced the experiment, the result of which is given, and worked the engine in the time named in his report. During the period of the experiment the furnace doors were open, the feed on, with 20 lbs. of steam, the throttle-valve partly shut off, and the engine making but 10 revolutions per minute. If then, under these circumstances, the most favorable for condensation, the steam-pipe 40 feet long, engine and side pipe 9 feet long, and cylinder 36 inches in diameter, condense only two gallons of water in as many hours *with* the trap attached, it can be easily estimated how much of that condensation is due to its agency.

On February 28, 1863, experiments were made on the engine of the steamboat *Louise*, running between Hunter's Point, L. I., and Thirty-fourth street, New York, which were conducted by Messrs. George P. Hunt and Benjamin Wood, U. S. N., (detailed for the purpose by Chief Engineer, B. F. Garvin, U. S. N.,) and other Engineers of reputation. The experiments were continued two hours, one with the trap attached, and one without, making four trips to each experiment, across the East River with a strong ebb tide, using the same throttle and injection, with the following results:—

WITH THE TRAP.

	First Trip.	Second Trip.	Third Trip.	Fourth Trip.
Steam upon starting, lbs.	24	25	24	25
" at end of experiments, lbs.	13	13	14	15
Vacuum, inches, . . .	26	26	26	26
Revolutions per minute, . . .	26½	27	27	26
Time per trip, minutes, . . .	4¾	5	4¾	6
Average Steam, . . .			19.12 lbs.	
" Vacuum, . . .			26 ins.	
" Revolutions, . . .			26.62 per min.	
" Time per trip, . . .			5.12 minutes.	

## WITHOUT THE TRAP.

	First Trip.	Second Trip.	Third Trip.	Fourth Trip.
Steam upon starting, lbs. . . .	27	25½	26	26½
" at end of experiments, lbs. . .	15	16	13	15½
Vacuum, inches, . . . .	23	25	25	22
Revolutions per minute, . . . .	24	23½	24	23½
Time per trip, minutes, . . . .	7½	7	7½	7
Average Steam, . . . .			20 56 lbs.	
" Vacuum, . . . .			23.75 ins.	
" Revolutions, . . . .			23 75 per min.	
" Time per trip, . . . .			7.25 minutes.	

NOTE.—During the first hour, while the engine was running with the trap, seventy-five measured gallons of water passed through it.

These experiments were made to demonstrate the utility of the instrument with a foaming boiler, three solid cocks of water being carried during the entire time the experiments were continued; whilst the following report of the Engineer of the same steamboat, running upon the same route, of experiments made under his personal supervision, were made to illustrate its value when every thing was in the ordinary running condition :

The experiments were commenced on the morning of March 2d, 1863, and were intended to have continued three days with the trap, and the same period without it. An abstract of the three days with the instrument is given, and but two days without it, as the globe cock (used for shutting off the trap from the lower end of the cylinder), became so much injured by the pressure of water behind it, that the trap could not be shut off, and the experiment was abandoned on the morning of the 7th inst.

## WITH THE TRAP.

March 2:—Made 40 trips. Running time, 3 hours, 18½ minutes. Average steam, 15.62 lbs. Do. time, 4 96 minutes.

March 3:—Made 39 trips. Running time, 3 hours, 7½ minutes. Average steam, 19.94 lbs. Do. time, 4.81 minutes.

March. 4:—Made 37 trips. Running time, 2 hours, 51½ minutes. Average steam, 16.14 lbs. Do. time, 4 63 minutes.

NOTE.—Burning eleven loads of coal, of 900 lbs. each; tallow was used in the cylinder four times, and the vacuum gauge showed 26 inches.

## WITHOUT THE TRAP.

March 5:—Made 39 trips. Running time, 3 hours, 27½ minutes. Average steam, 15.20 lbs. Do. time, 5 32 minutes.

March 6:—Made 36 trips. Running time, 3 hours, 15 minutes. Average steam, 15.35 lbs. Do. time, 5 42 minutes.

NOTE.—Burning eight loads of coal, of 900 lbs. each; tallow was used eight times, and the vacuum gauge showed 25 inches.

Annexed will be found the reports of Henry C. White, Eng. of the *Flushing*, Robert H. Spears, Chf. Eng. of the Houston Street Ferry Co., and James M'Farlan, Chf. Eng. of the Union Ferry Co., New York, to Mr. G. W. Furman, which are of interest, as detailing their experience of the workings of this instrument.

*Steamer Flushing, New York, May 5, 1862.*

DEAR SIR:—I have used your engine trap on the steamer *Flushing* for six months past, and am prepared to speak of its merits. The *Flushing* is a river steamer, with a beam engine, 36-inch cylinder, and ten feet stroke, whose boiler was constantly foam-



ing, and as a consequence I was obliged to use a large amount of tallow in her cylinder. During thirty days previous to attaching your trap, the amount of tallow used was 229 lbs., and during a subsequent thirty days, with the trap, only 30 lbs. were used. As no alteration had been made in the engine in the way of repairs, I attribute the difference in the quantity of tallow used to the presence of dry steam. During the time I had no trap I was troubled with "primage," but while using it I found the engine relieved of that trouble, as I could run with the "throttle" wide open, with high steam, without any water passing into the cylinder. I also found that in using the trap I did not require so frequent a renewal of the packing around the piston-rod, valve stems, &c., which I also attribute to the use of dry steam; and I also found an economy of 8 per cent. in coal in using the trap.

During the month of March the *Flushing* was chartered by the Government as a transport vessel, and then I found it a great advantage that the engine was always free of water and ready to start; the trap rendering it unnecessary to "blow through," or "warm up," before starting—as was proved, when, on one occasion, I lay for seven days with steam up, and did not touch the engine until the bell rang to start.

The water taken from the steam-chest by the trap was discharged into a tank on deck, which provided all the hot fresh water that was wanted for use in washing, scrubbing the paint-work, and in the kitchen, &c. While carrying troops, the hot water used by them for making coffee alone, averaged 435 gallons per day, by actual measurement. The Quartermaster, on being informed of this fact, directed the Captain of the boat to turn off twelve water casks, and to run with that number less than the regulations called for, for the use of the troops—the deficiency being supplied by the trap.

This is a plain statement of facts, which you are at liberty to use as you please. It is my opinion that the use of your trap will guarantee dry steam, economy of fuel, economy of lubrication in cylinders, and durability of packing, and that to insure these results, it is indispensable.

(Signed)

HENRY C. WHITE, Engineer.

*Houston Street Ferry Company, Williamsburgh, Sept. 3, 1861.*

DEAR SIR:—At your request I give you a statement of the working of your traps, as applied to the boats on our ferry.

The first trap put up by you was attached to the *Gerard Stuyvesant*, December 31, 1860, which proved so satisfactory that they were ordered on the *City of Williamsburgh* and *California*, April 15, 1861.

They have all worked to my entire satisfaction, requiring no care or attention.

I have to report:

Increase of speed, the engines making more turns than ever before.

A saving of fuel.

Decrease of wear and tear on packing, joints, and springs of engines.

Relief to air-pump, by decreasing the load of water formerly discharged.

A certainty of dry steam in the engine, and a more thorough condensation.

Dispensing with the necessity of "blowing through" the engine, when about to start in the mornings.

A saving of oil for cylinder; a pint per boat being the allowance per day.

A return of water from engine, with what oil may pass with it, to the tanks for feeding the boiler.

The impossibility of the engine becoming hot, while lying in the slip, which was of frequent occurrence before the traps were attached.

As a substitute for a priming or snifting valve, I can heartily recommend it, as, from its simplicity of construction, it cannot well get out of order; it is self-acting, and only requires for its welfare to be let alone.

They are also attached to the four boats of the East River Ferry Company, at Hunter's Point, with equal success.

(Signed)

ROBERT H. SPEARS, Chief Engineer.

Office of Union Ferry Co. of Brooklyn, February 26, 1863.

DEAR SIR: Your Steam Traps attached to the engines of our ferry-boats, fifteen in number (two vertical beam, the balance inclined), have given perfect satisfaction, and have accomplished all you promised, when you put up the first one in December, 1861.

The beneficial results are: an economy of tallow, *equal to FORTY lbs. per week, for each boat, or a saving of over SEVENTY-FIVE per cent. of the amount formerly used.*

An increase of speed, on account of being able to leave the bridge at full speed, therefore getting the boat well under way, before leaving the slip, and also by relieving the condenser and air-pump of the water of condensation and primage, and the additional injection-water required to cool it, and the consequent saving of fuel. As the engine is at all times free of water, the necessity of blowing it off is avoided, and there is never any danger arising from its collection in the cylinder. The packing, I find, lasts much *longer than formerly.* The water, as taken from the engine, is passed into the tanks for feeding the boiler.

Forty-seven years experience as a Steam Engineer, qualifies me to judge of its merits, and I do not hesitate to recommend it as a very valuable attachment to *any* engine.

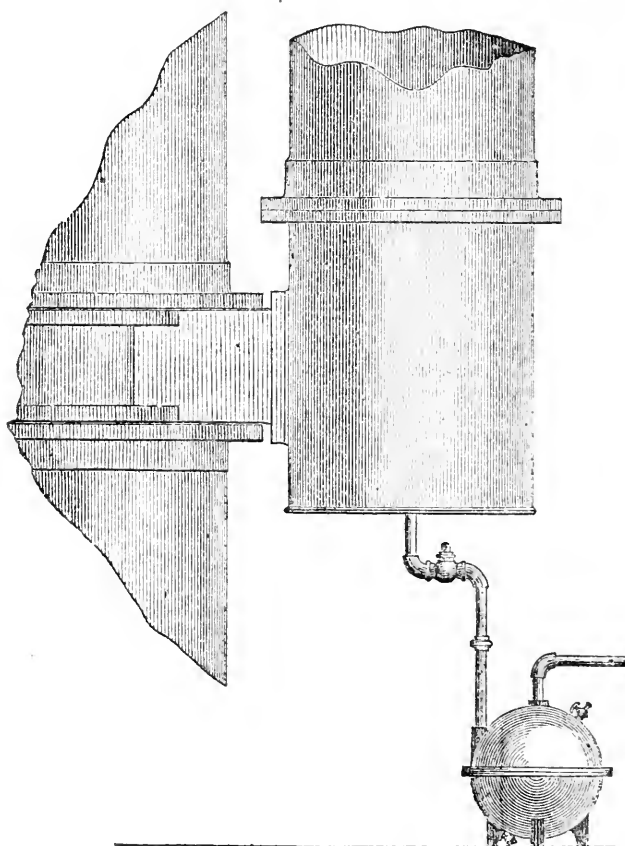
(Signed,)

JAMES McFARLAN, *Chief Engineer.*

For the Union Ferry Company.

That the manner of attaching the trap to the steam-chest of a vertical engine may be understood, I herewith annex a cut of its attachment:

TRAP AS ATTACHED TO STEAM-CHEST OF VERTICAL ENGINE.



## DIRECTIONS FOR USING THE TRAP.

When this instrument is attached to an engine, the check-valves must be placed horizontally, so that the water will flow freely through them. The same end of the valve that is placed next to the pump for feeding the boiler, must be placed nearest to the flow of water from the engine.

It requires to be so far filled with water, before first getting up steam, that globe B will float. If, by any accident, the slide-valve c becomes obstructed, and the steam blow through, it will be necessary to add sufficient water to again float globe B, which may be done by closing the cocks in the connexions, so far as to permit the water to pass into the trap in small quantities, or by pouring it through the hand-hole.

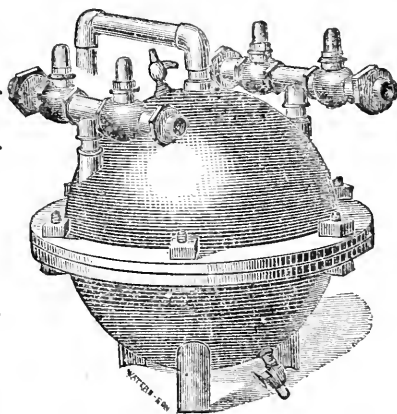
Before starting the engine, after lying idle several hours, open the air-cock on the top of shell A, and let it remain open until the air collected in the engine has passed through it.

The valves connecting the trap with the engine *should always be open.*

When much lubrication is resorted to in the cylinder, the check-valves may occasionally require to be cleaned of gum or grease. If, from the same cause, the slide-valve c becomes obstructed, it may be relieved by putting a small quantity of potash in globe B. So, too, if there ever be an accumulation of grease in shell A, it can be cleaned in the same manner. The trap can be relieved of dirt by removing the bonnet from the lower hand hole, and blowing steam through it.

*Locomotive Engines.*—This instrument is well adapted for relieving the cylinders of locomotive engines of water. As the boiler of a locomotive has large fire-surface and but little steam-room, primage must necessarily be of frequent occurrence. It is claimed by its inventor that its attachment to this character of engines will show an economy of fuel, an increase of speed, a removal of back pressure from the piston, by carrying off the water and allowing only dry steam to pass through the blast-pipe, an economy of oil in lubrication of cylinders, and a saving of packing. We herewith annex a cut illustrating the manner of its attachment to these engines.

TRAP FOR ATTACHMENT TO LOCOMOTIVE ENGINES.



In conclusion, I would add that this instrument has been successfully applied to the engines of the following steam vessels:—

Steamboats *Flushing, Broadway, Anna, City of Albany*, and twenty-seven others, plying between New York and Long Island, and New York and Jersey City.

Propellers *Falcon, Thomas Foulks*, and *Sze-Chuen*.

Steamers *Vixen, Corwin*, and *Hu-Quang*.

Steamships *Salvador, Matanzas, Parkersburgh*, and *Ta-kaing*.

Total, 41 steam vessels.

B.

*Signals to Prevent Collisions at Sea.*

From Mitchell's Steam Shipping Jour., April, 1863.

BOARD OF TRADE, Jan. 12, 1863.

1. By virtue of the "Merchant Shipping Act Amendment Act, 1862," and of an Order in Council, dated 9th January, 1863, the following Regulations, containing certain verbal Amendments, are substituted for the Regulations contained in the Schedule to the Act.

2. The following Regulations come into operation on the 1st of June, 1863.

3. The following Regulations apply to all Ships, whatever their Nationality, within the limits of British Jurisdiction, and to British and French Ships whether within British Jurisdiction or not.

4. The Order in Council containing these Regulations is published in the *London Gazette* of the 13th January, 1863.

T. H. FARRER, Assistant Secretary,  
Marine Department.

*Preliminary.*—Article 1. In the following Rules every steamship which is under sail and not under steam is to be considered a sailing ship; and every steam ship which is under steam, whether under sail or not, is to be considered a ship under steam.

*Rules Concerning Lights.*—Art. 2. The lights mentioned in the following Articles, numbered 3, 4, 5, 6, 7, 8, and 9, and no others, shall be carried in all weathers from sunset to sunrise.

Art. 3. Sea-going steamships when under way shall carry:

(a) *At the Foremast Head*, a bright white light so fixed as to show a uniform and unbroken light over an arc of the horizon of 20 points of the compass; so fixed as to throw the light 10 points on each side of the ship, viz: from right ahead to 2 points abaft the beam on either side; and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least five miles:

(b) *On the Starboard Side*, a green light so constructed as to throw a uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to two points abaft the beam on the starboard side; and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles:

(c) *On the Port Side*, a red light, so constructed as to show a uniform and unbroken light over an arc of the horizon of 10 points of the compass; so fixed as to throw the light from right ahead to 2 points abaft the beam on the port side; and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles.

(d) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Art. 4. Steamships when towing other ships shall carry two bright

white mast-head lights vertically, in addition to their side lights, so as distinguish them from other steamships. Each of these mast-head lights shall be of the same construction and character as the mast-head lights which other steamships are required to carry.

Art. 5. Sailing ships under weigh or being towed shall carry the same lights as steamships under weigh, with the exception of the white mast-head lights, which they shall never carry.

Art. 6. Whenever, as in the case of small vessels during bad weather, the green and red lights cannot be fixed, these lights shall be kept on deck on their respective sides of the vessel ready for instant exhibition; and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side.

To make the use of these portable lights more certain and easy, the lanterns containing them shall each be painted outside with the color of the light they respectively contain, and shall be provided with suitable screens.

Art. 7. Ships, whether steamships or sailing ships, when at anchor in roadsteads or fairways, shall exhibit, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light in a globular lantern of eight inches in diameter, and so constructed as to show a clear, uniform, and unbroken light visible all around the horizon, and at a distance of at least one mile.

Art. 8. Sailing pilot vessels shall not carry the lights required for other sailing vessels, but shall carry a white light at the mast-head visible all around the horizon, and shall also exhibit a flare-up light every fifteen minutes.

Art. 9. Open fishing boats and other open boats shall not be required to carry the side lights required for other vessels; but shall, if they do not carry such lights, carry a lantern having a green slide on the one side and a red slide on the other side; and on the approach of or to other vessel such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side, nor the red light on the starboard side.

Fishing vessels and open boats when at anchor, or attached to their nets and stationary, shall exhibit a bright white light.

Fishing vessels and open boats shall, however, not be prevented from using a flare-up in addition, if considered expedient.

*Rules Concerning Fog Signals.* Art. 10. Whenever there is fog, whether by day or night, the fog signals described below shall be carried and used, and shall be sounded at least every five minutes, viz:—

(a) Steamships under weigh shall use a steam whistle placed before the funnel not less than eight feet from the deck.

(b) Sailing ships under weigh shall use a fog horn.

(c) Steamships and sailing ships when not under weigh shall use a bell.

*Steering and Sailing Rules.*—Art. 11. If two sailing ships are meeting end on or nearly end on so as to involve risk of collision, the helms

of both shall be put to port, so that each may pass on the port side of the other.

Art. 12. When two sailing ships are crossing so as to involve risk of collision, then, if they have the wind on different sides, the ship with the wind on the port side shall keep out of the way of the ship with the wind on the starboard side, except in the case in which the ship with the wind on the port side is close-hauled and the other ship free, in which case the latter ship shall keep out of the way; but if they have the wind on the same side, or if one of them has the wind aft, the ship which is to windward shall keep out of the way of the ship which is to leeward.

Art. 13. If two ships under steam are meeting end on or nearly end on so as to involve risk of collision, the helms of both shall be put to port so that each may pass on the port side of the other.

Art. 14. If two ships under steam are crossing so as to involve risk of collision, the ship which has the other on her own starboard side shall keep out of the way of the other.

Art. 15. If two ships, one of which is a sailing ship and the other a steamship, are proceeding in such directions as to involve risk of collision, the steamship shall keep out of the way of the sailing ship.

Art. 16. Every steamship, when approaching another ship so as to involve risk of collision, shall slacken her speed, or, if necessary, stop and reverse; and every steamship shall, when in a fog, go at a moderate speed.

Art. 17. Every vessel overtaking any other vessel shall keep out of the way of the said last mentioned vessel.

Art. 18. Where by the above rules one of two ships is to keep out of the way, the other shall keep her course subject to the qualifications contained in the following Article.

Art. 19. In obeying and construing these Rules, due regard must be had to all dangers of navigation; and due regard must also be had to any special circumstances which may exist in any particular case rendering a departure from the above Rules necessary in order to avoid immediate danger.

Art. 20. Nothing in these Rules shall exonerate any ship, or the owner or master or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper lookout, or of the neglect of any precaution which may be required by the ordinary practice of seamen, or by the special circumstances of the case.

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For the Journal of the Franklin Institute.

*Description of Jenkins and Jumelle's Governors for Steam Engines.*

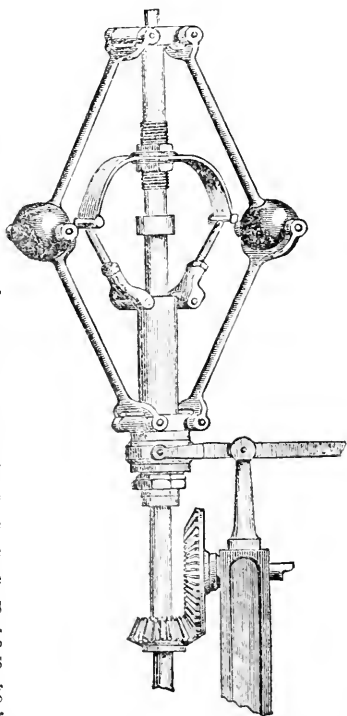
By H. HOWSON.

This invention by C. C. Jenkins and F. Jumelle of Philadelphia, consists in combining with a governor or spindle, a spring and rods arranged to form a knee joint, in the manner hereafter described, so that the force applied to overcome the rigidity of the spring, may

be transmitted through a leverage constantly increasing as the resistance of the spring increases, thereby equalizing the action of the spring.

The weighted arms of the governor are hung to the top of the spindle in the usual manner. To the weights of the arms are jointed the upper ends of rods, the lower ends of the latter being connected to a sleeve which is fitted snugly to, but arranged to slide freely on, the spindle. A spring is connected at a point midway between its opposite ends, to the spindle by means of nuts, which are adapted to the screwed portion of the said spindle. To one end of the spring is jointed a rod, and to the opposite end a similar rod, one rod being connected to a lug on one side, and the other to a lug on the opposite side of the upper end of the sleeve. The lower end of the latter has a recess for receiving the end of the usual governor lever through which the movement of the sleeve is communicated to the throttle valve of the steam engine. This recess formed by two collars, one of which is fast to the sleeve, the other being screwed on to the same, as is also a nut, the striking of which against a nut screwed on to the spindle, limits the downward movement of the sleeve, and consequently, the inward movement of the weights.

The sleeve is illustrated in the Figure as depressed to the limit of its downward movement, as regulated by this nut. As the governor revolves the weighted arms will fly out, and the sleeve will rise to an extent regulated by the speed of the governor, and the rigidity of the spring. Now supposing this spring acted directly on the sleeve without the intervention of the rods, it will be evident that the higher the sleeve rises through the centrifugal force of the weights, the greater will be the opposing force presented by the increased rigidity of the spring as the opposite ends of the latter are raised, consequently the governor will be irregular in its movement, the irregularity being in proportion to the difference of the rigidity of the spring as the ends of the latter are raised. By connecting the spring to the sleeve by means of the rods, however, the case is different, as they form with the sleeve and spring the well known knee-joint, so that, as the sleeve is raised, it acts on the spring through a leverage, gradually increasing as the sleeve rises, and as the rigidity of the spring increases. Thus when the sleeve is depressed to the limit of its downward movement,



the force exerted by the revolving balls tending to raise the ends of the spring, will be applied, as it were, through a lever of which the fulcrum is at a point near the centre, while as the spring rises, this fulcrum gradually approaches the farther end of the lever giving an increased leverage as the rigidity of the spring increases.

It will be evident that by transmitting the force imparted to the sleeve by the action of the revolving weights, to the spring through the medium of a knee-joint; the increasing rigidity of the spring as its opposite ends are raised, is counteracted by an increase in the force applied to raise the said ends, and consequently, that the action of the governor is uniform throughout.

For the Journal of the Franklin Institute.

### *Description and Trial Trip of the Steamship Continental.*

In the early part of the year 1862, the Ocean Steam Navigation Company asked proposals of the marine engine builders of this city for a propeller engine, competent to develop the same power as that of their paddle wheel steamship, *Keystone State*, whose cylinder has a bore of 80 inches, and length for 8 feet stroke; number of revolutions, 15 per minute with a steam pressure of 22 lbs., cut-off at one-half the stroke.

At the same time, proposals were given for the hull, to be built from the designs of Mr. J. W. Griffith, naval architect.

The contracts were awarded to Messrs. Merrick & Sons for the engine, and to Mr. J. W. Lynn for the hull. The following are the principal dimensions of both:—

*Hull.*—Length for tonnage, 238 ft. 6 ins. Do. for deep load-water line, 221 ft. 7 ins. Breadth of beam at midship section, 38 ft. Depth of hold, 16 ft. Length of engine and boiler space, 33 ft. Length of shaft, forward of stern post, 76 ft. Draft of water at deep load line, 12 ft. Draft of water at below pressure and revolutions, 11 ft. forward, 11 ft. 6 ins. aft. Area of immersed section at 12 ft. draft, 390 sq. ft. Masts and rig, schooner.

*Engine.*—Diameter of cylinder, 50 ins. Length of stroke, 3 ft. 9 ins. Maximum pressure of steam in pounds, 35 lbs. Cut off,  $\frac{2}{3}$  stroke. Maximum revolutions per minute, 56.

*Boilers.*—Two. Length of boilers, 12 ft. Breadth or face, 20 feet. Number of furnaces in each, 6. Breadth of furnaces, 2 ft. 9 ins. Length of grate bars, 6 ft. 8 ins. Number of flues or tubes in each, 336. External diameter of flues or tubes, 3 ins. Length of flues or tubes, 7 ft. 6 ins. Heating surface, total, 4860 sq. ft. Diameter of smoke-pipe, 6 ft. Height, do. 40 ft. Description of coal, anthracite. Draft, natural. Consumption of coal per hour,  $1\frac{1}{2}$  tons.

*Propeller.*—True screw. Diameter, 12 ft. 6 ins. Length of Blades, fore and aft, 2 ft. 6 ins. Pitch, 24 ft. Number of blades, 4. Average revolutions per minute, 52.

*Remarks.*—Fitted with a surface condenser; also, with J. V. Merrick's patent double ported balanced slide valve, and with a small slide valve for warming up and starting the engine. Independent fire and bilge pump. Independent engines for hoisting cargo, and also the ashes from the fire room upon a labor saving plan devised by Mr.



Alexander Heron, Agent of the Company. Mr. Heron also arranged coal bunks from the upper deck downwards so as to cause nearly their entire contents to run towards the bunker doors by gravity, thus dispensing with the coal passers. Fifty tons of coal are carried in bunks built over the boilers, intended as a reserve to be used in an emergency.

The following is an account of her first performance, which took place November 26th, 1862.

*Trial Trip of Steamer CONTINENTAL, November 26th, 1862.*

	Time. h. m.	Steam.	Vacuum.	Revolu- tions.	Throt- tle.	Tide.	Wind.	
Navy Yard,	10 48	20½	22	44	Wide	Ebb.	Abeam.	
Point House,	11 9½	20½	22	41	"	"	Starboard bow	
Fort,	11 35	24	20½	48	"	"	"	
Chester Pier,	12 16	26	20½	52	"	"	"	
Within ½ mile of Brandy- wine light,	1 42	32	20	52	¾	Flood.	Port Quarter.	{ Stopped 8 minutes to avoid several vessels in the channel. { Rounded to and start- ed up the river.
Marcus Hook,	2 16	29½	22	51	½	"	Abeam.	
Chester,	2 31½	29½	22	51	¾	"	"	
Fort,	3 7	30	21½	54	¾	"	"	
Navy Yard,	3 36	34½	21	56	Wide.	"	Ahead.	

By taking the distance from Marcus Hook to the Navy Yard, the longest distance run between measured points made without a stop, at 20½ miles, and allowing 2½ miles per hour for the tide and dividing by the time, we will have speed of ship through the water in miles per

hour, thus:— $\frac{20.25 - 2.5}{3.36 - 2.16} = 13.3125$  miles.

The wind, being unfavorable, retarded the ship somewhat, as she was very high out of the water; and the speed in calm weather through the water would most likely be about 13½ miles, and might exceed that if she were loaded so as to immerse the whole of the propeller, which, it will be seen, was fully ½ its diameter above the water. The trial was satisfactory to all concerned; the time occupied in running between certain points was almost identical with that of the *Keystone State* on her trial, as:—from Marcus Hook to Chester, 30 seconds less; and, from Chester to Navy Yard one minute more. The two hulls had about the same immersed section which shows that the engine of the *Continental* came up to the requirements of the contract.

The balanced slide valve worked admirably; one man being able to shift with ease, the slot link from ahead to backing point by means of a 34-inch hand wheel upon the same shaft with a 4-inch pinion, working into a rack attached to the link. The valve is 34 ins. wide by 38 ins. long. Steam of the before mentioned tension when pressing upon an unbalanced valve of this size exerts a force =  $34 \times 38 \times 34\frac{1}{2}$  lbs. = 44574 lbs. and as friction of cast iron upon cast iron when lubricated

is about  $\frac{1}{10}$ th total weight, or pressure on surfaces, we have 4457 lbs. required to move the valve. The entire motion of the valve is 7 ins. and the power required to work it (still supposing it to be unbalanced) would be at 56 revolutions of engine  $\frac{4457 \times \frac{7}{12} \times 2}{33000} = 8.82$  horses.

An examination of the valve after two voyages had been made from New York to New Orleans and back, and one voyage from Philadelphia to New York and back showed that nothing better, as a balanced slide valve need be desired, the rubbing surfaces being polished like mirrors.

Messrs. Merrick & Sons applied this balanced valve to the engines of U. S. Steamer *New Ironsides*, and are about to place it on those of U. S. Steamer *Yantic* and Ram *Tonawanda* now building at their works. J.

For the Journal of the Franklin Institute.

### *Particulars of the Ship Cremorne.*

Hull built by Maxson, Fish & Co., Mystic, Conn. Commander, Capt. Isaac D. Gates. Intended service, California and East India Trade. Owners, Lawrence, Giles & Co., New York.

*Hull*.—Length over all, 200 ft. Breadth of beam, 39 ft. Depth of hold, 14 ft. Do. between decks, 9 ft. Half poop, including mainmast,  $4\frac{1}{2}$  ft. Keel, 15 by 24 ins. Frames—molded, 17 ins. Bilge strakes, 12 ins., diminishing to 8 ins. Lower deck beam, 15 by 15 ins. Main deck, do., 14 by 12 ins. Garboard strake, 6 ins. Bottom planking, 4 ins. Wales, 5 ins. Tonnage, 1413 tons.

*Masts, &c.*—Foremast, 74 ft. Diameter of do., 31 ins. Mainmast, 77 ft. Diameter of do., 32 ins. Mizzen-mast, 70 ft. Diameter of do., 25 ins. Topmasts, 46 ft. Lower Yards, 72 ft. Lower Topsail Yards, 63 ft. Upper do., 50 ft.

*Remarks*.—This vessel is well built, and in every respect thoroughly and heavily fastened with composition spikes, copper butt bolts, and treenails. Her keel is of white oak, also her keelsons of three thicknesses, all edge-bolted. Her frames are of white oak and white chestnut, very heavy; ceiling, white oak, beams and deck frame, white chestnut, all full kneed with haemetac and oak knees; clamps are edge-bolted; patent windlass. Has six hooks and pointers forward, and same number aft. Launched, March 19th, 1863. B.

For the Journal of the Franklin Institute.

### *Speed of Ships.*

The Barque *Nelly* of New Castle, Del., 506 tons burthen, belonging to Mr. J. C. Brooks of that place, recently made the passage from New York to Sligo in 18 days. When it is considered she contended with easterly winds, and the vessel was deeply laden with grain, this passage is extraordinary. It has rarely been equalled, much less surpassed.

The Clipper Ship *Daring*, Capt. Simonson, made the run recently from New York to Liverpool in 19 days. Her outward passage to Liverpool was made in 17 days—thus making the round voyage in 36 days.

The Clipper Ship *Snow Squall*, of New York, left Sandy Hook at noon, December 2d, 1862, and arrived at Melbourne, Australia, February 16th, 1863, making the passage from port to port in 75 days.

The Clipper Ship *Dacon*, Capt. Chase, has made the passage from Buenos Ayres to New York in 38 days.

The Steamer *Columbia*, of New York, left the Navy Yard, Washington, May 11th, 1862, and arrived at her dock, East River, in 30 hours—the shortest run between these points on record.

The Steamer *Baltic*, of New York, left Annapolis, Md., April 24th 1862, and arrived at her dock, East River, in 29 hours. B.

### Solid Drawn Gun Barrels.

From the London Practical Mechanic's Journal, Jan., 1863.

On the 1st December, 1862, by the permission of the Court of the Gunmaker's Company, some very interesting experiments were made at the proof-house, Whitechapel, London, on a fowling piece and rifle barrel made by the new process of solid cold-drawing, of which Messrs. Christoph, Harding, and Hawksworth are the patentees. By this process the metal is drawn cold, by means of the hydrostatic press, and thus a saving is effected to the extent of one-half the metal now consumed by the hot process. For instance, about 10 lbs. of metal is now used in making an Enfield rifle barrel, which, when made, weighs only  $4\frac{3}{4}$  lbs., the remainder of the metal being consumed in the manufacture. By the present process two rifle barrels can be drawn from the same amount of metal, equally strong in every respect to those now made. The barrels tried were drawn from a new kind of cast steel, and subjected to the following proofs:—

#### Rifle Barrel.

First proof, $7\frac{1}{2}$ drachms of powder, 2 wads and 1 ball of 520 grains,	No injury.
Second, Same powder and 2 balls,	“
Third, 10 drachms of powder and 3 balls,	“
Fourth, 15 drachms of powder and 5 balls,	“

The smooth bore was put to the following proofs:—

First proof, $10\frac{3}{4}$ drachms of powder, 2 wads and 1 round ball of 24 to the pound,	No effect.
Second, Same powder, 2 wads and 2 round balls,	“

It was then determined to burst this barrel by putting in a proof charge and two balls, and filling the muzzle of the barrel to the extent of two inches with moist clay. The result was, that the barrel burst at the bottom of the clay, only tearing about two inches of its length, and showing no other signs of injury. A similar barrel, proved

at Birmingham, only slightly bulged, with 20 drachms of powder and 3 balls.

Several specimens were also exhibited, showing the applicability of this process to drawing hollow tubes in iron or steel of any shape, and almost any reasonable length. At present we understand it has not been applied to tubes of more than  $1\frac{3}{4}$  inches diameter, or to a length exceeding 30 feet. Its extension to larger tubes is evidently a mere question of mechanical power. The patentees estimate that by the adoption of their process the cost of iron gun barrels will be reduced to one-third the present price, and that a cast steel barrel can be supplied at the present cost of an iron one.

That a very great increase of cohesive strength *in the longitudinal direction* is produced by the forcible extension, either by rolling or by drawing (and whether cold or hot) wrought iron, has long been known.

In the case of fine iron wire, such as pianoforte strings, the increase of ultimate longitudinal strength is quite surprising, being as much frequently as an increase of from 30 tons per square inch ultimate strength in the original forged or rolled slab from which the wire is to be drawn, up to 120 tons per square inch in the wire itself. The nature of the molecular changes produced by this powerful compression laterally and extension longitudinally of the crystals of the iron has been pointed out by Mr. Mallet, in his work on the Physical Properties of the Metals for Artillery, &c., and shown to result from his law—"That in all crystallizable solids the principal axes of symmetry of the integrant crystals, tend to place themselves at right angles to the direction of greatest pressures within the mass"—which is in a drawn or rolled rod longitudinally, *i. e.*, at right angles to the pinch of the draw-plate or rolls. It is in virtue of this that the hot rolled rod of rivet iron, is stronger and tougher longitudinally than the lump out of which it is rolled, and if a piece of this hot rolled rivet rod be cut off, and drawn out into fine wire, its strength and toughness will be still further exalted.

If the rod be rolled cold, the same result proportionally to the pressure and mass follows. This effect of cold rolling on iron was announced some few years since as quite a new discovery, and Mr. Fairbairn made some experiments on the increase of strength conferred. If the bar or the wire be heated red hot however, and cooled suddenly, or be slowly annealed, though some increase of strength remains, a great deal of the increased strength is found again to have been lost.

There is no doubt whatever that a cold drawn gun barrel, therefore, will have a very high amount of longitudinal strength, but it by no means follows that any like increase of strength as against bursting by the charge of powder, through circumferential strains, or any increase *at all*, as respects this, shall result.

If a rod forged in a twisted set of spirals like a twist barrel, were drawn or rolled cold, and after its extension would bear further forcible cold twisting in the same direction, we think it not improbable that some increment of strength as against bursting might be obtained, though we say this with reserve; but if so, this would not survive the

rods being annealed. Any rod or barrel thus treated, or drawn or rolled cold, has its particles thrown into tensions and internal strains, which, at every particle cut off, either from the outside or the inside, by filing or boring, &c., will cause the whole mass to alter its shape by twisting or bending spontaneously. In fact, this actually takes place now in the Enfield forged barrels inevitably, to a sufficient extent, to make final straightening by the hammer necessary. Of course, the same may be done with cold drawn barrels, but the internal strains will be far more vehement, and we apprehend such barrels might show a persistent tendency to return to a crooked form.

However, the method presents other advantages in point of economy, &c., which are in no way problematical; and we should be greatly pleased to see some really well devised experiments made by water pressure, upon cold drawn and upon hot rolled barrels from the same iron, as to their relative bursting resistances, a question which, certainly, the preceding experiments do not solve.

Our remarks are not meant as condemnatory of the proposed method, nor even as discouraging, we but wish to place in contact with what is proposed, the ascertained facts of metallurgy already known.

For the Journal of the Franklin Institute.

*Notes of Shipbuilding and the Construction of Machinery in New York and vicinity.*

(Continued from p. 179.)

*The Steamer Falcon.*—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. Route of service, New York to Providence. Owners, Commercial Steamboat Co.

*Hull.*—Length on deck, 160 ft. Breadth of beam, 34 ft. 6 ins. Depth of hold, 11 ft. Do. to spar-deck, 18 ft. Draft of water, 11 ft. Frames—molded, 13½ ins.—sided, 8 ins. apart at centres, 24 ins. Tonnage, 875 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 30 ins. Length of stroke of piston 3 ft.

*Boilers.*—Two—tubular—located in hold, and use blowers to furnaces.

*Propeller.*—Diameter, 11 ft. 6 ins. Blades, 4. Material, cast iron.

*Remarks.*—This steamer is of white oak and chestnut. She is fastened with copper and treenails in the most approved manner. Her rig is that of a three-masted schooner; she has one smoke-pipe, one independent steam fire and bilge pump, two bilge injections, bottom valves to all openings in her bottom, and bunkers of wood. The *Falcon* is an excellent vessel for the service for which she was constructed.

*The Steamer Thorn.*—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, Charles Mallory & Co.

*Hull.*—Length on deck, 125 ft. Breadth of beam, 26 ft. Depth of hold, 7 ft. Do. to spar-deck, 13 ft. 6 ins. Draft of water, 7 ft. Frames—molded, 11 ins.—sided, 7 ins.,—apart at centres, 26 ins. Tonnage, 225 tons.

*Engines.*—Vibrating lever. Diameter of cylinders, 20 ins. Length of stroke of piston, 18 ins.

*Boilers.*—One—tubular—located in hold, has a water bottom, and uses a blower to furnaces.

*Propeller.*—Diameter, 7 ft. 6 ins. Pitch, 12 ft. Blades 4. Material, cast iron.

*Remarks.*—This vessel is of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are filled in solid for half length; she has knees under her main deck, her rig is that of a schooner, and her water-ways are of pine. She has one independent steam fire and bilge pump, one bilge injection, and bottom valves or cocks to all openings in her bottom. The *Thorn* will give satisfaction wherever employed, as she is a vessel exceedingly well built.

*The Steamer New England.*—Hull built by John Englis, New York. Machinery constructed by Morgan Iron Works, New York. Route of service, Boston to St. Johns, N. B. Owners, John B. Coyle & Co.

*Hull.*—Length on deck, 230 ft. Breadth of beam, 32 ft. Depth of hold, 12 ft. 6 ins. Draft of water, 7 ft. 6 ins. Frames—molded, 14 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, foretopsail schooner. Tonnage, 896 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 52 ins. Length of stroke of piston, 11 ft.

*Boilers.*—One—flue—located on deck. Uses blowers to furnaces.

*Paddle Wheels.*—Diameter, 27 ft. Number of blades, 27. Material, iron. Have sponsons one-half width.

*Remarks.*—This vessel is of white oak, &c., and fastened in the best manner. Her frames are not filled in solid, but they have iron straps, double and diagonally laid,  $4$  by  $\frac{1}{2}$  inches, extending around them, and also a head strap of iron,  $6$  by  $\frac{3}{4}$  inches, running around head of frame. She is coppered; has knees under her main deck, and is built in every respect in the most substantial manner. She is supplied with an independent steam fire and bilge pump; in fact, with all that will make a steamer of her class sea-worthy.

*The Steamer Ta-Kaing.*—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Dickson & Co., Scranton, Pa. Route of service, coast of China. Owners, Olyphant & Sons, New York.

*Hull.*—Length on deck, 154 ft. Breadth of beam, 23 ft. Depth of hold, 12 ft. 6 ins. Do. to spar-deck, 19 ft. 6 ins. Draft of water, 11 ft. Frames—molded, 14 ins.—sided, 5 ins.—apart at centres, 28 ins. Rig, brigantine. Tonnage, 505 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 36 ins. Length of stroke of piston, 3 ft. 8 ins.

*Boilers.*—One—tubular—located in hold, and does not use blowers to her furnaces.

*Propeller.*—Diameter, 10 ft. 8 ins. Pitch, 19 ft. Material, cast iron.

*Remarks.*—This vessel is built of white oak, chestnut, &c., and fastened in the most approved manner. In her construction are combined strength, beauty of model, and speed. She has one independent steam fire and bilge pump, one bilge injection and bottom valves, or cocks, to all openings in her bottom. She is admirably arranged

for protection against fire, everything that experience has suggested, being resorted to in this respect. Her bunkers are of wood and iron. We bespeak a successful career for the *Ta-Kaing*.

*The Steamer Blackstone*.—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed by Corliss, Nightingale & Co., Providence, R. I. Route of service New York to New Orleans. Owners, J. & M. Smith & Co.

*Hull*.—Length on deck, 175 ft. 6 ins. Breadth of beam, 34 ft. 3 ins. Depth of hold, 12 ft. 3 ins. Do. to spar-deck, 18 ft. 3 ins. Draft of water, 12 ft. Frames—molded, 14 ins. sided, 10 to 12 ins.—apart at centres, 26 ins. Rig, Brig. Tonnage, 947 tons.

*Engines*.—Horizontal. Diameter of cylinder, 48 ins. Length of stroke of piston, 2 ft. 4 ins.

*Boilers*.—Four—tubular—located in hold, and use a blower to furnaces. These boilers are of a peculiar construction, from an original design of the builders of her machinery.

*Propeller*.—Diameter, 12 ft. 4 ins. Pitch, 16 ft. Blades, 4. Material, cast iron.

*Remarks*.—This steamer is of white oak, chestnut, &c., and square fastened with copper and treenails. She is strengthened in the most approved manner, and is an excellent sea-going vessel. Her frames are not filled in solid; she is fitted with knees under both main and spar decks; her water ways are of yellow pine, and she has four cargo ports.

*The Steamer Fire Cracker*.—Hull built by John Euglis, New York. Machinery constructed by Neptune Iron Works, New York. Route of service, Tang-tsze river, China. Owners, H. W. Johnson & Co.

*Hull*.—Length on deck, 252 ft. Breadth of beam, 36 ft. Depth of hold, 12 ft. Draft of water at launching, 4 ft. 9½ ins. Do. with machinery, 6 ft. 6½ ins. Do. at load line, 8 ft. Area of immersed section at load draft, 5864 sq. ft. Weight of hull, 524 tons. Frames—molded, 14 ins.—sided, 6 ins.—apart at centres, 24 ins. Rig, topsail schooner. Tonnage, 1046 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 60 ins. Length of stroke of piston, 12 ft.

*Boilers*.—Two—flue—located in hold; have water-bottoms, and one blower to each.

*Paddle Wheels*.—Diameter 30 ft. Material, iron. Have guards one half width and slatted.

*Remarks*.—This steamer is of white oak and chestnut, and is square fastened with copper and treenails. Around her frames are double and diagonally laid iron straps, 4½ by ½ inches, making them of great strength. The model of this vessel is very handsome, and her whole construction reflects great credit on her builder.

The Singapore (China) *Times* of August 23d, last, says:—"The American steamer *Fire Cracker*, Capt. H. W. Johnson, left New York at 4 P. M. on Saturday, June 7, arriving at St. Vincents on the 18th, at 4 A. M.; remained there till the 26th, when she left for Cape Town, arriving July 13th, remaining only half-an-hour, and leaving London papers of June 9, beating the mail to this point, eight days. Finding the harbor of Cape Town too rough to lie in, she ran around to Simon's bay, a distance of 57 miles, in 3 hours and 8 minutes. Was

detained there  $9\frac{1}{2}$  days for coal, on account of bad weather; left on the 23d, experienced very rough weather off the Cape, and arrived there August 1st, in  $8\frac{1}{2}$  days; remained there until the 5th, when she left for Singapore. The winds were so strong after leaving Mauritius, that she was obliged to run north five days before making a course for Singapore, where she arrived on the evening of the 20th inst. from Mauritius, a distance of 3920 miles. Her last three days run were 348, 332, and 329 miles. Running time from New York,  $52\frac{1}{2}$  days, being the quickest time ever made between the two ports of New York and Singapore."

*The Steamer Anna J. Lyman.*—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Curtis & Schapter, New York. Route of service, New York Harbor. Owners, B. Coffin & Co.

*Hull.*—Length on deck, 126 ft. Breadth of beam, 23 ft. Depth of hold, 8 ft. 6 ins. Draft of water, 5 ft. 4 ins. Frames—molded, 10 ins.—sided, 6 ins.—apart at centres, 22 ins. Tonnage, 231 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 34 ins. Length of stroke of piston, 7 ft.

*Boilers.*—One—flue—located in hold. Has no water bottom, and uses a blower to furnaces.

*Paddle Wheels.*—Diameter, 20 ft. Material, wood.

*Remarks.*—This is a well built, staunch steamboat, proving quite remunerative to her owners, in her present employment. She is of white oak, chestnut, &c. and is extremely well fastened with spikes, copper, treenails, &c. She has one smoke-pipe and her bunkers are of wood.

*The Steamer Haze.*—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, Charles H. Mallory & Co.

*Hull.*—Length on deck, 132 ft. Breadth of beam, 25 ft. 2 ins. Depth of hold, 9 ft. 8 ins. Draft of water, 7 ft. 6 ins. Frames—molded, 11 ins.—sided, 6 ins.—apart at centres, 26 ins. Rig, schooner. Tonnage, 298 tons.

*Engines.*—Vibrating lever. Diameter of cylinder, 20 ins. Length of stroke of piston, 18 ins.

*Boilers.*—One—tubular—located in hold, has water bottom; does not use blowers.

*Propeller.*—Diameter, 8 ft. Pitch, 12 ft. Blades, 4. Material, cast iron.

*Remarks.*—This vessel is one of the best of her class. She is a superior craft in every respect. Her frames are of white oak, chestnut, &c., and square fastened with copper and treenails; they are filled in solid under engines and boiler. She has knees under both main and spar decks; her water ways are of white pine. She has one independent steam fire and bilge pump, one bilge injection and bottom valves or cocks to all openings in her bottom. A prettier and more sea-worthy steamer of her tonnage, is seldom seen than the *Haze*.

*The Steamer Union.*—Hull built by Charles H. Mallory, Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, Hargous & Co., New York.

*Hull.*—Length on deck, 219 ft. 6 ins. Breadth of beam, 34 ft. Depth of hold 17 ft.



Do to spar deck, 24 ft. 6 ins. Draft of water, 16 ft. 3 ins. Frames—molded, 14 ins.—sided, 9 ins.—apart at centres, 27 ins. Rig—brigantine. Tonnage, 1253 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 36 ins. Length of stroke of piston, 3 ft.

*Boilers.*—Two—return tubular—length, 19 ft. 6 ins. Shell, 12 ft. Have water bottoms. Do not use blowers.

*Propeller.*—Diameter, 13 ft. Pitch, 18 ft. Blades, 4. Material, cast iron.

*Remarks.*—This steamer is of white oak, chestnut, &c., and is square fastened with copper and treenails. Her frames are filled in solid for whole length, and they have iron straps, double and diagonally laid,  $4\frac{1}{2}$  by  $5\frac{1}{8}$  inches, running around them. She has knees under both main and spar decks, one bulkhead, and water ways of pine. The cabins of this vessel extend her entire length, and are capable of seating 200 persons. They are exquisitely finished with polished oak paneling. The sofas in the forward cabin are of oak and plush velvet. Bath rooms, toilets, &c., are circulated throughout the vessel. Upon the trial trip of this steamer, she made thirteen miles per hour with 23 pounds of steam, her propeller making 66 revolutions per minute; it must be understood that her boilers were very “oily,” and her coal, unfortunately, bad. The *Union* was built for the especial purpose of being put upon the route between New York and Havana, but being, in every respect, such an excellent steamer, she was taken by the Government for their use.

*The Steamer Convoy.*—Hull built by Thomas Stack, Williamsburgh, L. I. Machinery constructed by Fulton Iron Works, New York. In Government Service. Owners, Arthur Leary & Co., New York.

*Hull.*—Length on deck, 180 ft. Breadth of beam, 26 ft. 3 ins. Depth of hold, 9 ft. 2 ins. Draft of water, 5 ft. Frames—molded, 12 ins.—sided, 6 ins.—apart at centres, 26 ins. Tonnage, 377 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 10 ft.

*Boilers.*—One—tubular—located in hold; does not use blowers; has water bottom.

*Paddle Wheels.*—Diameter, 25 ft. 6 ins. Material, iron.

*Remarks.*—This vessel is of white oak, &c., and well fastened with copper, &c. Around her frames iron straps extend, giving them great strength. She is supplied with one independent steam fire and bilge pump, and all necessary injections, valves, &c. The period this vessel has been in service, though limited, has given her owners ample opportunity to note her sea-worthiness, her excellent carrying capacity, and the successful working of her machinery.

*The Steamer Eagle.*—Hull built by J. Westervelt & Co. Machinery constructed by Allaire Works, New York. Route of service, New York to Havana. Owners, Spafford, Tillston & Co, New York.

*Hull.*—Length on deck, 237 ft. 6 ins. Breadth of beam, 37 ft. Depth of hold, 14 ft. 6 ins. Do to spar deck, 21 ft. 6 ins. Draft of water, 13 ft. Frames—molded, 15 ins.—sided, 13 ins.—apart at centres, 30 ins. Rig, Brig. Tonnage, 1570 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 75 ins. Length of stroke of piston, 12 ft.

*Boilers.*—Two—flue—located in hold; does not use blowers; have water bottoms.

*Paddle Wheels.*—Diameter, 30 ft. Material, iron.

*Remarks.*—This steamer is built of white oak, chestnut, &c., and square fastened with copper and treenails. Around her frames extend iron straps, double and diagonally laid, 4 by  $\frac{3}{8}$  inches, thus rendering them staunch and of great strength. She has knees under her main and spar decks, water ways of pine, and bunkers of wood and iron. She is fitted with one independent steam fire and bilge pump of large size, bilge injections, and bottom valves to all openings in bottom. Upon the route of her service, the *Eagle* has given great satisfaction, carrying large numbers of passengers, and heavy cargoes of freight. This is not at all astonishing, as she is an excellent and comfortable vessel in every respect.

*The Steamer Thames.*—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed by C. H. Delameter, New York. Route of service, New York to New London. Owners, George Greenman & Co.

*Hull.*—Length on deck, 145 ft. Breadth of beam, 30 ft. Depth of hold, 9 ft. Do. to spar deck, 16 ft. Frames—molded, 12 ins.—sided, 10 ins.—apart at centres, 24 ins. Draft of water, 9 ft. Rig, three-masted schooner. Tonnage 362 tons.

*Engines.*—Vertical direct. Diameter of cylinder, 31 ins. Length of stroke of piston, 2 ft. 6 ins.

*Boilers.*—One—tubular—located in hold; uses a blower to furnaces. Has water bottom.

*Propeller.*—Diameter, 10 ft. Pitch, 16 ft. Blades, 4. Material, cast iron.

*Remarks.*—This vessel is of white oak, &c., and square fastened with the usual materials in the best manner. She has knees under main and spar decks, and her frames are filled in solid under engine. She has an independent steam fire and bilge pump, one bilge injection, and bottom valves to all openings in her bottom. Her spar deck is enclosed, and she is fitted with an independent rudder post.

*The Steamer Touitia.*—Hull built by Thos. Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Route of service, Coast of China. Owners, McCredy, Mott & Co., New York.

*Hull.*—Length on deck, 149 ft 6 ins. Breadth of beam, 26 ft. 7 ins. Depth of hold, 10 ft. 2 ins. Draft of water, 8 ft. 6 ins. Frames—molded, 11 ins.—sided, 11 ins.—apart at centres 22 ins. Rig, foretopsail schooner. Tonnage, 496 tons.

*Engines.*—Vertical direct. Diameter of cylinder, 26 ins. Length of stroke of piston, 2 ft. 2 ins.

*Boilers.*—One—flue—located in hold; does not use blowers. Has water bottom.

*Propeller.*—Diameter, 9 ft. Pitch, 15 ft. Blades, 4. Material, cast iron.

*Remarks.*—This vessel is of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are not filled in solid, but around them extends iron straps, double and diagonally laid,  $2\frac{3}{4}$  by  $\frac{5}{8}$  ins., giving them strength. She has knees under her deck, water ways of white pine, one smoke pipe, one independent steam fire and bilge pump, one bilge injection, bunkers of wood, and bottom

valves or cocks to all openings in her bottom. The *Touitia* has beauty of model, and all else to make her a successful steamer. The vessels from the hands of Mr. Collyer have always sustained a reputation that was ever flattering to him, and an honor to American Naval Architecture.

*The Steamer Seagull*.—Hull built by Maxson, Fish & Co., Mystic, Conn. Machinery constructed by C. H. Delameter, New York. Route of service, New York to Providence, R. I. Owners, Commercial Steamboat Co.

*Hull*.—Length on deck, 165 ft. Breadth of beam, 33 ft. 8 ins. Depth of hold, 10 ft. Do. to spar deck, 17 ft. 6 ins. Draft of water, 12 ft. Frames—molded, 13 ins.—sided, 10 ins.—apart at centres, 26 ins. Rig, three-masted schooner. Tonnage, 500 tons.

*Engines*.—Vertical direct. Diameter of cylinder, 36 ins. Length of stroke of piston, 3 ft.

*Boilers*.—One—tubular—located on deck; does not use blowers.

*Propeller*.—Diameter, 12 ft. Pitch, 18 ft. Blades, 4. Material, cast iron.

*Remarks*.—This vessel is of white oak and chestnut, and fastened with copper and bolts. Her frames are filled in solid under engine and thirty feet forward. The outside planking is 4 inches thick; from the floor heads to lower deck, it is sealed with white oak 5 inches thick, and 4 inches from lower deck to main rail on planksheer. The vessel is supplied with one independent steam fire and bilge pump, and fitted with bilge injections and bottom valves to all openings in her bottom. Her bunkers are of wood. Great precaution has been observed in her construction to avoid fire, her security and provisions in this respect being excellent. Her owners are sanguine that she will prove a vessel worthy of the patronage of the traveling public.

*The Steamer Henry Burden*.—Hull built by Webb & Bell, Greenpoint, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. In government service. Owners, P. A. Burden & Co.

*Hull*.—Length on deck, 133 ft. 6 ins. Breadth of beam, 24 ft. Depth of hold, 9 ft. Draft of water, 3 ft. 6 ins. Frames—molded, 10 ins.—sided, 6 ins.—apart at centres, 24 ins. Tonnage, 280 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 32 ins. Length of stroke of piston, 3 ft.

*Boilers*.—One—flue—located in hold; does not use blowers. Has no water bottom.

*Paddle Wheels*.—Diameter 28 ft. Material, wood.

*Remarks*.—This vessel is of white oak, &c., and well fastened. She is supplied with one independent steam fire and bilge pump, and one bilge injection. She was designed and built for service in and around the harbor of New York, but the Government finding her well adapted for service at Fortress Monroe, and along the coast in that vicinity, took possession of her, and are now using her as a transport.

*The Steamer Matteawan*.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co., New York. Route of service, New York to Keyport. Owners, Keyport and Monmouth Steamboat Co.

*Hull.*—Length on deck, 210 ft. Breadth of beam, 28 ft. Depth of hold, 8 ft. 8 ins., Draft of water, 4 ft. 6 ins. Frames—molded, 16 ins.—sided, 7 ins.—apart at centres, 24 ins. Tonnage, 495 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 42 ins. Length of stroke of piston, 12 ft.

*Boilers.*—One—flue—located in hold; uses a blower to furnaces. Has no water bottom.

*Paddle Wheels.*—Diameter, 28 ft. Material, iron and wood.

*Remarks.*—This steamer is built of white oak, &c., and well fastened. She has one independent steam fire and bilge pump, and one bilge injection. Her bunkers are of wood; she has a saloon upon her promenade deck and two smoke-pipes. The *Matteawan* is an excellent vessel of her class, and has given much satisfaction upon the route of her service. She is comfortable, finely fitted up, and of greater speed than is usual to anticipate of a steamer of her character. B.

New York, April 15, 1863.

(To be Continued.)

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Translated for the Journal of the Franklin Institute.

### *Theory of Steel.*

M. H. Caron in a communication made to the French Academy of Sciences attributes the combination of iron with carbon or other elements of the same family by which tempered steel is formed, to the sudden shrinking of the mass, which he considers as analogous to the instantaneous compression produced by hammering. In illustration of this point he found that by hammering a bar of iron heated to a bright redness, on an anvil covered with powdered charcoal, the face of the bar in contact with the charcoal, was, in spots, converted into steel, and capable of resisting the file. His researches also confirm the results of previous experiments, that the density of steel is decreased by tempering. In one specimen, after thirty successive temperings, the density was reduced from 7.817 to 7.743.

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### *Cloths Rendered Uninflamable by Sulphurous Vapor.*

From the Practical Mechanic's Journal, April, 1863.

M. Sauvageon, a French investigator, has discovered that cotton cloth which has been exposed for a certain time to the vapor of burning sulphur, assumes such an amount of incombustibility that, although it will char and become brittle when held over the flame of a spirit lamp, it cannot be made to take fire, while under like conditions similar cloth, but unprepared in this way, inflamed immediately. If the alleged facts be borne out in practice, the problem is solved, for the simplest domestic means may be devised for subjecting, after being washed, all white clothing to the vapor of sulphur, which will tend to make it still whiter. Moreover, it may not prove necessary to repeat the exposure so often.

*The New Gun Metal.*

From the London Chemical News, No. 167.

A letter in the *Times* from one of our most distinguished metallurgists, signed with the well known "Y," gives some interesting particulars respecting the new gun metal lately invented in Austria by Baron von Rosthorn. Before giving any account of this new alloy, the writer states his opinion that the days of wrought iron are numbered, and that its place will be soon supplied by steel in some form or other. The new alloy, which has received the name of "sterrometal," from a Greek word signifying tough or firm, is composed of copper, spelter, iron, and tin, in proportions that may be slightly varied without much affecting the result. In color it resembles brass rather than gun metal; it is very close in its grain, and free from porosity. It is possessed of considerable hardness, and will take a very fine polish. Several eminent Vienna engineers have tried it for the cylinders of hydraulic presses with great success. Two specimens of the alloy have been submitted to rigorous tests by the Polytechnic Institute of Vienna and the Imperial Arsenal. The proportions used in each case were the following:—

	Polytechnic Institution.	Imperial Arsenal.
Copper, . . . . .	55.04	57.63
Spelter, . . . . .	42.36	40.22
Iron, . . . . .	1.77	1.86
Tin, . . . . .	0.83	0.15
	<hr/> 100.00	<hr/> 99.86

The specimen tested at the Polytechnic Institute gave the following results per sectional inch (English):—A bar prepared by simple fusion, bore a weight of twenty-seven tons. Forged red hot it broke at thirty-four tons. Drawn cold, at thirty-eight tons; the figures in the case of the specimen tried at the Imperial Arsenal being twenty-eight, thirty-two, and thirty-seven tons respectively; while the best English gun metal, containing ten per cent. of tin and ninety per cent. of copper, broke at eighteen tons under similar circumstances. The specific gravity of the metal is about 8.37 when forged hot. These results, which are official, are truly astounding when we consider that the average breaking strain of wrought iron, as given by Mr. Anderson, of Woolwich Arsenal, is only twenty-six tons, whilst that of the best steel is only thirty-five tons per sectional inch. The elasticity of the sterrometal is also very great. It may be stretched  $\frac{1}{1500}$ th of its length without undergoing permanent elongation; gun metal giving only  $\frac{1}{1590}$ th, and wrought iron  $\frac{1}{1500}$ th. No surprise is, therefore, felt when we are told that a tube of sterrometal is capable of resisting a pressure of 763 atmospheres, a tube of wrought iron of similar size and form giving way under 267 atmospheres.

Quoting Mr. Anderson, the writer concludes by saying that the best alloy for guns is yet to be discovered. It seems to us, however, that sterrometal is very near perfection. The subject of alloys is one that, with constant and persevering experiment, must yield most valuable

results, and we strongly advise any young chemist desirous of laurels and fortune to take up the matter. It seems singular that, with all our boasted knowledge of chemistry and metallurgy, there are but half-a-dozen alloys that may be turned to economic uses.

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*Gas Purification by Oxide of Iron.* By GEORGE ANDERSON.

From the *Gas Light Journal*, No. 271.

SIR:—As the question of gas purification by oxide of iron is likely to be introduced to your pages again, through the proceedings now instituted to obtain a prolongation of the patent, it may be interesting to your readers to have the following facts placed before them.

Being compelled to abate the lime nuisance at the Dover Works some three years ago, we provided ourselves with a quantity of oxide of iron, purchased from the patentee, Mr. Hills, which we worked until it became thoroughly saturated with sulphur, and no longer capable of revivifying in the open air, as is usually adopted. Desiring to know whether I could recover it by expelling the sulphur it contained, by heat, I charged retorts with it, until I had obtained sufficient to fill a purifier, added sawdust to it, and began the use of it again. I found its purifying powers restored. Also that it revivified on exposure to the air as before, and that it could be used over and over again.

I then erected a kiln for the purpose of restoring the whole of my stock, and the process has been continued for about eighteen months with perfect success.

In this process, the material is kept at a dull red heat for ten or twelve hours, and has become, I would say, anhydrous.

I think some of the evidence, on former trials, was to the effect that oxide of iron once made anhydrous, was useless in the purification of gas. This statement is at variance with the facts above stated.

16, Adam Street, Strand, March 5, 1863.

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*Magneto-Electric Lighthouse.* By F. H. HOLMES.

From the *London Athenæum*, Jan., 1863.

May I ask your permission to offer a few observations on the notice of the magneto-electric light which appeared in the *Athenæum* of the 29th of November last? The details therein given were correct *at the dates referred to*, and the well-wishers of the light cannot but welcome so clear and concise an account of the application of the invention to lighthouses; but the time which has elapsed since has been occupied in perfecting the efficiency of the light, and it is hoped that you will allow the result to be recorded.

The improvement has arisen from using a different lamp. That instrument is no longer a delicate piece of complicated clock-work, but so simple an affair that the movement of the carbons is entirely accomplished with one wheel and one pinion; and the lamps which have been in use at Dungeness for nearly seven months, and for some time

before that on my own premises, have never been even opened to be oiled. When to this is added the fact that the light, if arbitrarily extinguished, will now instantly re-light itself, a certainty of action has been arrived at which leaves little to be desired. The liability to sudden and spontaneous extinction has also disappeared. The light was burnt every day in the International Exhibition from half-past one o'clock to five without once going out : and there is reason to believe that at Dungeness a steadiness and continuity practically complete has been obtained.

The only element of interruption that remains arises from certain impurities, silica or metallic residuum, in the carbons ; and when they have decomposed to a point where iron or antimony occurs, there is a slight change of color, an absolutely momentary flicker (not an extinction), which, though it would cease to exist if carbons could be obtained quite pure, is practically of no consequence whatever.

This improvement in the lamp has of course altered the relative simplicity of the two systems of oil and electricity enormously. There is really nothing now to look after in the latter that the customary attendant on a steam-engine could not learn efficiently in a few hours ; and the chance of break-down to that which has now become ordinary mechanism is no greater than exists every day, without (as a rule) occurring, in every engine-room in the kingdom, and is, of course, less than a sea-going steam-vessel risks with impunity for months together. If, in addition to this, it is considered that oil, although in a sense simple, is liable to an adulteration very difficult to detect ; and that in proportion to adulteration is the necessity for frequent trimming ; and that, with the best oil known, every four-wicked lamp *must* be trimmed at least once every night, during which time,—from five to fifteen minutes,—the only light in the lantern proceeds from the hand-lamps of the keepers, it follows that the Magneto-Electric Light is preferable to the oil lamp on account, amongst other things, of its unbroken continuity. The question of expense, even if that were very much greater than it is, is one that could hardly affect its use in a country which, from its wealth of life and merchandise afloat, has such need to employ the best light that can be had ; but, although where the large and very costly apparatus and lantern for the oil system have been already procured, there would be no set-off to the cost of the small engine and the magneto-electric machine itself, yet at a new station, where the whole thing had to be done from the beginning, the saving in the difference of size of lantern and of apparatus, and the easiness with which the machinery could be placed in the light-house tower immediately under the lantern, so that no more than the customary two men would be necessary, would reduce the excess of outlay to a minimum : the proportions being for the magneto-electric light,—first cost, about one-sixth more, and for the maintenance about half as much again. When there were two lights adjacent, a portion of the machinery necessary for one could be applied to both, and the working expenses would then be, for the two lights, in the proportion of 1·142 magnetic to 1·000 oil, or thereabouts.

The great questions involved are quality, intensity, and efficiency of light. Regarded from this point, the magneto-electric is very much the cheaper; that is to say, it gives a great deal more for the money. Moreover, the intensity and penetrative power of the light can be increased indefinitely, at a very small ratio of increased cost.

If space could be afforded to me, I should have no difficulty in showing, by considerations of pure science, that from the very nature of light itself, the magneto-electric light *must* be enormously greater in penetrative power than the flame of the oil lamp; but it is sufficient for the present to express my thanks that through the medium of your pages the attention of the general public has been directed to the facts by which this is being practically proved.

Northfleet, Jan. 1, 1863.

*On the Results of some Experiments on the Mechanical Properties of Projectiles.* Read by Dr. Fairbairn, the President of the Section.

From the London Practical Mechanic's Journal, Feb., 1863.

He commenced by stating that, in the investigations which had taken place with regard to projectiles and armor-plated ships, one great difficulty that had arisen was to get good plates of sufficient thickness, and vessels of sufficient tonnage to carry those plates. It appeared that they were limited to plates of five inches in thickness; with plates heavier than that, a ship would not be what was technically called "lively." He had attended the experiments at Shoeburyness from the commencement, and they had reference to the force of impact. He would state the results of the more recent experiments, which had not yet been published. The first series of experiments had reference to the quality of the plates and the properties of the iron best calculated to resist impact. There were three qualities required: first, that the iron should not be crystalline; but secondly, that it should be of great tenacity and ductility; and thirdly, that it should be very fibrous. The mean statical resistance to crushing of the two flat-ended specimens of cast-iron is 55.32 tons per square inch. The mean resistance of the two round-ended specimens is 26.87 tons per square inch. The ratio of resistance, therefore, of short columns of cast iron with two flat ends to that of columns with one flat and one round end is as 56.32 to 26.87, or as 2.05 to 1,—an extremely close confirmation of Prof. Hodgkinson's law. Applying this same rule to the steel specimens, it would appear that the flat-ended shot should have sustained a pressure of 180 tons per square inch before fracture. In the experiment it actually sustained 120 tons per square inch without injury, excepting a small permanent set. In the experiments with cast iron, the mean compression per unit of length of the flat-ended specimens was .0665, and of the round-ended .1305. The ratio of the compression of the round-ended to the flat-ended shot was, therefore, as 1.96:1, or nearly in the inversed ratio of the statical crushing pressures. Applying this law to the case of the steel flat-ended specimen, it may be concluded that the compression before fracture would have been only .058 per unit of length. The determination of the statical crushing pressure of



the flat-ended steel shot is 180 tons per square inch and its compression as .058 is important, on account of the extensive employment of shot of this material, size, and form in the experiments at Shoeburyness. In the case of the lead specimens, the compression with equal weights was the same whether the specimen were at first round-ended or flat-ended. This is accounted for by the extreme ductility of the metal and the great amount of compression sustained. In regard to the wrought iron specimens, it may be observed that no definite result is arrived at, except the enormous statical pressure they sustain, equivalent to 78 tons per square inch of sectional area, and the large permanent set they then exhibit:—

	Statical Resistance in tons per square inch	Dynamical Resistance in foot lb. per square inch.
Cast iron, flat-ended, . . .	55 32	776.8
Cast iron, round-ended, . . .	26 87	821.9
Steel, round-ended, . . .	90.46	2515.0

In the experiments on the wrought iron specimens, the flat-ended steel specimens, and the lead specimens, no definite termination was arrived at, the material being more or less compressed without any fracture ensuing. The mean resistance of the specimens of cast iron is 300 foot-pounds per square inch; that of the specimen of steel is 2515, or rather more than three times as much. The conditions which would appear to be desirable in projectiles, in order that the greatest amount of work may be expended on the armor-plate, are—1. Very high statical resistance to rupture by compression. In this respect, wrought iron and steel are both superior to cast iron; in fact, the statical resistance of steel is more than three times, and that of wrought iron more than two-and-a-half times that of cast iron. Lead is inferior to all the other materials experimented on. 2. Resistance to change of form under great pressures. In this respect, hardened steel is superior to wrought iron. Cast iron is inferior to both. The shot which would effect the greatest damage to a plate would be one of adamant, incapable of change of form. Such a shot would yield up the whole of its *vis viva* to the plate struck; and, so far as experiment yet proves, those projectiles which approach nearest to this condition are the most effective. The President stated that steel shots might be made at a comparatively small cost. M. Bessemer had told him, that if he had a large order he could produce steel shots at a little more than the price of iron; but if the ingots as cast had to be rolled or hammered to give them fibre, they would cost near £30 a ton, instead of £8 or £10 per ton.

Mr. J. Nasmyth inquired whether chilled cast iron flat-headed shot had been tried? The process of chilling cast iron was very simple and inexpensive. If chilled flat-ended cast iron shot had not been tried, it was very desirable it should be—Dr. Fairbairn said they had not been tried; but he believed that shot thus made being hardened to a certain

depth, the velocity being the same, would, in striking the object, break as if it had not been hardened at all. However, he would have experiments made; and he hoped that before the next meeting of the Association the matter would be proved experimentally.

Proc. British Association, Oct. 6, 1862.

### *Iron Vessels in the French Navy.*

From the London Mechanics' Magazine, January, 1863.

Mr. Donald McKay, in his report on the French navy, says the reason why iron war vessels are somewhat at a discount in France, is the insuperable difficulty of preventing their fouling. We have now another signal example of the same difficulty amongst ourselves:—

The *Urgent*, iron screw troopship, lately paid out of commission at Portsmouth, on her return from service in China, has been placed in dock at Portsmouth, and her bottom found to be covered with barnacles and other marine adhesions. The *Urgent* had been previously, during the term of her commission, carefully coated over her bottom with various so-called patent preservative compositions. The result has only been to coat her bottom with shell matter and weeds more plentifully than could possibly have been the case without them. We have before had occasion to remark on the apparent uselessness of these anti-fouling preparations, as illustrated by vessels docked at Portsmouth.

### *On the Manufacture of Nickel.* By LEWIS THOMPSON, M.R.C.S., &c.

From Newton's London Journal, February, 1863.

Commercial nickel is a very impure article, and bears no more relation to pure nickel than brass or bell-metal does to copper. The following table will show its average composition, as it is found in the market:—

	English.	English.	German.	German.	French.
Nickel, . . .	86.0	84.5	75.7	80.9	77.5
Cobalt, . . .	6.5	8.2	2.2	5.2	3.7
Copper, . . .	—	0.6	12.5	7.7	10.2
Iron, . . .	1.4	1.1	0.4	1.2	1.1
Arsenic, . . .	1.3	0.4	2.6	3.8	2.8
Zinc, . . .	2.0	0.7	4.1	0.5	1.4
Manganese, . . .	0.2	0.8	—	—	0.6
Sulphur, . . .	1.7	2.2	2.3	0.2	1.1
Carbon, . . .	0.5	0.9	0.2	0.1	0.7
Silica and Alumina, . . .	0.4	0.6	—	0.4	0.9

From what I have before said, there is every reason to suppose that our accounts of metallic nickel relate to an alloy of that metal with cobalt, in greater or smaller proportion; that, in fact, absolutely pure nickel has not hitherto been obtained. Pure nickel is, however, much more easily made than pure cobalt, for its affinity for oxygen is much less. Taking advantage of this fact, I made up a quantity of pure

oxide of nickel into a paste by means of a little water, and forced this paste through a perforated earthenware plate, so as to form it into a granulated mass; when this mass had been thoroughly dried, I introduced it into a porcelain tube, and after heating it red hot, I passed a current of pure hydrogen gas over it, and continued this until it had become cold. The gray metallic sponge thus produced was fused with a little borax in a crucible, lined with pure alumina, and yielded a beautiful white silvery looking button of the weight of 620 grains; its specific gravity was 8.575, and it was almost as soft as copper. Its malleability seemed very great indeed, for a piece of it was rolled out nearly to the thinness of tin foil; it showed, however, a disposition to tarnish after a few days' exposure to the air, and became then of a pale yellow color—a kind of green-sickness tinge. Its magnetic properties were less decided than those of either cobalt or iron; and judging by the globular form and other evidences of perfect fusion in the button, I believe that nickel is much more fusible than the two metals just mentioned. When portions of it were melted with copper and zinc, in the quantities usually adopted to form alabaster, it produced a compound vastly superior in appearance to any of the miserable make-shifts that now disgrace our markets. Indeed, I am quite convinced that it would well repay any respectable person to commence the manufacture of pure nickel; and it would not surprise me, if a compound of aluminium and nickel could be formed, which, for beauty of appearance, might equal silver, and surpass it in durability and freedom from sulphurous deterioration.

Whilst alluding to the advantages of an improvement in the manufacture of nickel, it may not be amiss for me to notice two points of some importance in the way of improvement. At present the extraction of nickel from the ore is made to depend very much upon the affinity of arsenic for that metal, so as to form with it an arseniuret of easy fusibility and sufficient specific gravity to separate freely from the melted slag or gangue; and for this purpose large quantities of arsenic are employed by the workmen, not only to the detriment of their own health, but also to the injury of their neighbors. This pernicious practice is quite unnecessary, as I have myself proved by experiments upon a large scale; for example, after carefully roasting six hundred weight of the common ore of nickel, which is an arsenio-sulphuret, I mixed it with half its weight of chalk, and threw the mixture into a cupola furnace in full blast; the result was, that the lime of the chalk formed, with the quartz and oxide of iron in the ore, a perfect flux, whilst the oxide of nickel, being easily reduced to the metallic state, fell, in that condition, into the well of the cupola, from whence it was run out in a melted form, and readily separated from the slag. There was no appreciable loss of nickel in this operation, and the rough metal was found to contain 88 per cent. of pure nickel, the rest being cobalt and iron, with a little sulphur, but no arsenic could be detected in it; moreover, this rough metal might, from the cheapness of the process, have been profitably sold at 3s. per lb., and was decidedly more pure than the ordinary commercial nickel.

The other point to which I have alluded is applicable to the wet mode of separating nickel, and depends upon a fact hitherto, I believe, unnoticed by chemists. If we have in solution a mixture of the sulphates of nickel, cobalt, zinc, manganese, iron, and copper, we have only to add to this solution in a warm state, as much sulphate of ammonia as it will dissolve, and then set it aside to cool. Almost every particle of the nickel and cobalt will separate as a green crystallized powder, and leave the other metals in solution. The explanation is very simple. The sulphates of nickel and cobalt form triple salts or alums with the sulphate of ammonia, and these salts are absolutely insoluble in a cold saturated solution of sulphate of ammonia, particularly when this solution is slightly acidulous. I shall conclude these remarks upon nickel by stating that this metal appears to possess the property of "welding" like iron. At my request, a workman heated two small bars of nickel, which had been previously powdered over with borax, the bars were heated in a forge, and the two hot ends "jumped" together, that is to say, the white hot ends were forcibly driven one against the other by gentle blows with a hammer, applied to the other ends, the symmetry of the bar being preserved by blows applied laterally. Although the point of junction was afterwards subjected to much twisting, straining, and so forth, with a view to test its cohesive power, yet it showed no signs of weakness, even after much cold hammering.

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### *Uninflammable Stuffs.*

From the Lond. Mechanics' Magazine, March, 1863.

On this important subject the French Academy of Sciences has received a report from MM. Payen, Velpéau, and Rayer, in which M. A. Chevalier's paper, sent in to the Academy on the 25th of January last, is discussed. From this report it appears that only three salts have hitherto been found that may be successfully applied to the purpose in question, viz: that of preventing ladies' dresses from catching fire. There are many other salts that would do the same, but not without spoiling the dye, or the gloss, or the texture of the stuff, &c. Of the three in question, the sulphate and phosphate of ammonia have the inconvenience of being decomposed by the heat of a smoothing-iron; but they are applicable in those manufactures where stuffs are stiffened by the action of hot air or cylinders heated by steam. They exercise no action upon either the thread or the color of the stuff. The phosphate of ammonia may be mixed with half its weight of hydrochlorate of ammonia. To obtain an efficacious solution, 20 per cent. of this mixture must be dissolved in water. A solution of 7 per cent. of sulphate of ammonia produces the same effect, and is therefore the most economical salt that the trade can employ. But in those cases in which the smoothing-iron cannot be dispensed with, as in linen, for instance, a solution of 20 per cent. of tungstate of soda should be preferred. To obtain the desired effect, all these solutions must be applied to the stuffs after they have been stiffened and dried, because starch is always used in a weaker solution than that required

for these salts. Acid tungstates destroy the thread of cotton stuffs, like borax, alum, and other substances previously recommended. The tungstate of soda is prepared in Cornwall, where the tin mines yield a large quantity of wolfram. It costs from £ 12 to £ 18 per ton, or about 4f. per kilogramme. The sulphate of ammonia costs about £ 14 per ton; it is produced in gasworks, and has hitherto been used for manure.—*Galignani.*

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PROCEEDINGS OF THE BRITISH ASSOCIATION.

From the London Athenæum, Oct., 1862.

*Section G.—Mechanical Science.*

Mr. W. Smith read the Report of the Committee appointed at the last meeting of the Association to inquire into the causes of Railway Accidents. This Report was simply provisional, pointing out the steps now in progress for collecting information.

Messrs. Williamson of Liverpool, made a communication relative to the merits of Wooden and Iron Ships, with regard to cost of repairs and security for life, and in the event of accidents at sea; calling attention in particular, to an iron ship of their own, the *Santiago*, which met with a collision, the consequences of which would have been absolute destruction of the vessel had she been of wood; whereas, being of iron and having water-tight compartments, the vessel was able to pursue her voyage, and was repaired at the cost of a few hundred pounds, instead of several thousands, which would have been necessary had she been made of wood, and could have been preserved from foundering.

Prof. W. J. M. Rankine read a paper "On the Form and Motion of Waves at and near the Surface of Deep Waters."—This paper was a summary of the nature and results of a mathematical investigation, the details of which have been communicated to the Royal Society. The investigations of the Astronomer-Royal and of Mr. Stokes on the question of straight-crested parallel waves in a liquid, are based on the supposition that the displacements of the particles are small compared with the length of a wave. They proceed by a method of approximation, which Mr. Stokes has carried furthest. Hence it has been very generally inferred that the results of those investigations when applied to waves in which the displacements are considerable, as compared with the length of wave, are only approximate. In the present paper, the author proves that one of those results,—viz: in very deep water the particles move with a uniform angular velocity in vertical circles, where radii diminish in geometrical progression with increased depth, and consequently, that surfaces of equal pressure, including the upper surface, are trochoidal,—is exact for all possible displacements, how great soever. The author proves further, that the centres of the orbits of the particles in a given surface of equal pressure stand at a higher level than the same particles do when the liquid is still, by a height which is equal to the height due to the velocity of revolution of the particles; and that, consequently, the mechanical energy of a wave is half actual and half potential (half being due to motion and half

to elevation), and the destructive power of a wave is double of that due to the motion of its particles alone. The hydrostatic pressure at each individual particle during the wave motion is the same as if the liquid were still. In an Appendix to the paper is given the investigation of the problem, to find approximately the amount of the pressure required to overcome the friction between a trochoidal wave-surface and a wave-shaped solid in contact with it. The application of the result of this investigation to the resistance of ships was explained in a paper read to the British Association in 1861, and published in various engineering journals in October of that year.

A paper was brought before the Section by Mr. C. Vignoles, "On the Practice and Principles of Diverting Rivers, and the Stoppage of Breaches in Embankments."—The author proceeded to describe a method successfully adopted by him in dealing with the River Ebro. The plan he pursued was one very generally adopted at the present day by the Dutch engineers,—namely, gradually shallowing the river throughout at the required spot by means of fascine work. It consists in forming large rafts of fascines, and floating them down to the desired place; loading them evenly with stones, and thus sinking them down to the bottom; and repeating the operation till they rise above the surface of the water. This, he contended, was a more judicious plan than that of piling from the sides to the centre, the result of which was the continual narrowing of the water way, which caused the tide or stream to rush through with such accelerated violence so as frequently to destroy the works before they were completed; whilst, by the use of fascines, the water was gradually shallowed all over and its force checked by degrees. The Dutch engineers had long since given up the piling system for such purposes.

A paper by Mr. J. Sewell, was read, "On the Prevention of Railway Accidents."—The author considered that the main cause of accidents was the want of punctuality in the trains; and that this arose mainly from the overloading of them, which rendered it impossible that they could keep time. Engines were made to perform certain work and draw certain loads, and if these were exceeded it was impossible that time could be kept. This was a matter that the public could not ascertain for themselves, and he, therefore, advocated the importance of having engines licensed like boats, omnibuses, &c., by Government to draw certain loads; and a statement giving that information should be placed conspicuously on the engine. This would prevent the overloading, as it would be in the power of every passenger to see whether the power of the engine was duly apportioned to the carriages it had to draw.

A discussion took place, in which it was objected that such a proceeding would be impracticable, looking at the variety of work which an engine had to perform, by reason of varying inclines, the state of the weather, and the uncertainty as to the weight of carriages and the varying number of passengers.

"On an Improved Painting Telegraph Apparatus," by Mr. T. Sor-tain:

"On the Manufacture of Armor Plates," by Mr. A. C. Tylor.

"On Instruments for observing the Motion of Vessels at Sea, with reference to Sea-sickness," by Mr. J. W. Osborne.

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FRANKLIN INSTITUTE.

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*Proceedings of the Stated Monthly Meeting, April 16, 1863.*

John Agnew, Vice President, in the Chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

Donations to the Library were received from the Royal Astronomical Society, the Royal Geographical Society, and the Statistical Society, London; the Canadian Institute, Toronto, and Major L. A. Huguet-Latour, Montreal, Canada; Frederick Emmerick, Esq., Washington City, D. C.; E. W. Hilgard, Jackson, Mississippi; J. Spencer Turner, Chicago, Illinois; Young Men's Mercantile Library Association, Cincinnati, Ohio; Frank H. Stover, Cambridge, Mass.; Young Men's Association, Buffalo, and Dr. Warren Rowell, City of New York; Hon. A. H. Glatz, Senate of Pennsylvania, and T. C. Zulich, Esq., Harrisburg, Pennsylvania; Messrs. John Pennington & Son, Geo. M. Conarro, Esq., H. P. M. Berkinbine, Esq., the Girard College for Orphans, and Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer's statement of the receipts and payments for the month of March was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (3) were proposed, and the candidates (5) proposed at the last meeting were duly elected.

Mr. Washington Jones exhibited an improved Stop Valve, the invention of H. G. Ludlow of New York. The valve, in this instance, slides vertically across the opening, and when down, is kept in close contact with the seat by a wedge which is loosely secured to the back of the valve. The motion of the spindle in closing the valve forces down the wedge, and presses the face of the valve firmly against the seat.

Mr. Thomas Shaw exhibited a glass tube which he fractured by introducing into the same a few grains of sand. Mr. S. stated that the tube was like those usually employed for steam gauges and capable of bearing an internal pressure of over 1000 pounds, but that rubbing a few grains of sand or emery against the inside surface, was certain to cause the fracture, although it did not always follow immediately, he having known the tube to lay two weeks before breaking. Mr. Shaw in explanation of the cause of this, stated, that he attributed it to the manner of making the tubes, and that when they were cooled and straightened, by rolling them upon a flat surface, before they were hardened, it was impossible to fracture them in such a manner.

*A Comparison of some of the Meteorological Phenomena of MARCH, 1863, with those of MARCH, 1862, and of the same month for TWELVE years, at Philadelphia, Pa.*  
 Barometer 60 feet above mean tide in the Delaware River. Latitude  $39^{\circ} 57\frac{1}{2}'$  N.; Longitude  $75^{\circ} 10\frac{1}{2}'$  W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	March, 1863.	March, 1862.	March, 12 Years.
Thermometer—Highest—degree,	63-00°	56 00°	78-50°
“ “ date, .	25th.	11th & 12th.	3d. 1861.
“ Warmest day—Mean,	56-67	48-30	66-00
“ “ date, .	25th.	12th.	3d. 1861.
“ Lowest, degree, .	15-00	22-00	4-00
“ “ date, .	5th.	1st.	10th, 1856.
“ Coldest day—Mean,	24-17	32 30	11-50
“ “ date, .	15th.	1st.	10th, 1856.
“ Mean daily oscillation,	13-81	14-44	14-89
“ “ range, .	6-17	3-95	6-16
“ Means at 7 A. M., .	32-29	31-24	35-48
“ “ 2 P. M., .	40-94	44-21	46 66
“ “ 9 P. M., .	35-82	39-18	40-19
“ “ for the Month,	36-35	39 21	40-78
Barometer—Highest—Inches, .	30 384 in.	30-173 in.	29-522 in.
“ “ date, .	21st.	9th.	3d. 1852.
“ Greatest mean daily press.,	30 311	30-156	30-445
“ “ date, .	20th.	9th.	11th, 1852.
“ Lowest—Inches, .	29 422	29-276	29-158
“ “ date, .	25th.	3d.	17th, 1854.
“ Least mean daily pressure,	29-497	29-390	29 324
“ “ date, .	25th.	16th.	19th, 1857.
“ Mean daily range, .	0-214	0-173	0-195
“ Means at 7 A. M., .	29-882	29-804	29 851
“ “ 2 P. M., .	29-829	29-747	29-795
“ “ 9 P. M., .	29 880	29-795	29-831
“ “ for the Month,	29-864	29-782	29 826
Force of Vapor—Greatest—Inches,	0-445 in.	0-389 in.	0-549 in.
“ “ date, .	25th.	10th.	18th, 1859.
“ “ Least—Inches,	0-050	0-081	0-023
“ “ date, .	15th.	26th.	5th, 1858.
“ “ Means at 7 A. M., .	0-147	0-149	0-163
“ “ “ 2 P. M., .	0-151	0-159	0-178
“ “ “ 9 P. M., .	0-153	0-171	0-179
“ “ “ for the month,	0-150	0-159	0-173
Relative Humidity—Greatest per cent.,	94 per ct.	95 per ct.	100 per ct.
“ “ date, .	11th.	3d & 15th.	Often.
“ “ Least per cent, .	26-0	25-0	16-0
“ “ date, .	27th.	27th.	31st, 1860.
“ “ Means at 7 A. M., .	75-4	74-4	73-7
“ “ “ 2 P. M., .	56-4	56-2	53-2
“ “ “ 9 P. M., .	70-2	70-5	67-9
“ “ “ for the month,	67-4	67-0	61-9
Clouds—Number of Clear days,* .	4	9	9-9
“ “ Cloudy days, .	27	22	21-1
“ “ Means of sky cov'd at 7 A. M.,	68-1 per ct.	62-3 per ct.	59 8 per ct
“ “ “ “ 2 P. M., .	72-3	66-1	60 9
“ “ “ “ 9 P. M., .	55-2	65-8	44 9
“ “ “ for the month,	67-4	64-7	55-2
Rain and melted Snow—Amount .	6-379 in.	3-509 in.	3-074 in.
No. of days on which Rain or Snow fell.	16	11	10-7
Prevailing Winds, . . .	N. 37° 45' W. . 235	N. 43° 07' W. . 377	N. 70° 38' W. 303

\* Less than one-third covered at the hours of observation.



JOURNAL  
OF  
THE FRANKLIN INSTITUTE  
OF THE STATE OF PENNSYLVANIA,  
FOR THE  
PROMOTION OF THE MECHANIC ARTS.

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JUNE, 1863.

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CIVIL ENGINEERING.

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*Supply of Water to Cities.—The Cisterns of Venice.*

From the Practical Mechanic's Journal. April, 1863.

EVERY city, and all living things, are supplied with water by rain in one form or other, namely, by that fraction of the total rain that falls, which is not again rapidly evaporated, but collected upon the surface, is drawn into reservoirs of some shape or sort. Most generally these reservoirs are found in the rivers or perennial streams, that pass cities and towns founded on their banks;—sometimes, but rarely, in lakes, upon the shores of which, or upon islands wholly water-surrounded, they have been fixed; as in the cases of the ancient capital of Mexico and of Mantua, &c. More rarely still, and chiefly as a result of modern engineering, the reservoir has been an artificial one, collecting its waters from the rain falling on “gathering grounds,” *i. e.*, upon a determinate surface of dry ground. Spring wells, Artesian or otherwise, are no exception, as all water-bearing strata are but subterraneous reservoirs of rain, with the advantage, and sometimes the disadvantage, that here the rain, in its permeation of the earth to the fissures beneath, becomes filtered and purified, or takes up new mineral matter, and may change its temperature inconveniently, as well as its chemical constitution.

Most rarely of all, and as quite an exceptional case, a few communities at great elevations, or in the more rigorous climates of tempe-

rate zones, have been dependent for water, upon the snow and ice melting close around them:

Thus there does not seem anything strange at first sight in a city supplied wholly by rainfall; but there is everything both remarkable and unusual, in a great city dependent for its water supply upon *the surface only which itself covers*, and collected altogether in small and artificial reservoirs. Yet such is the water supply of Venice, the inhabitants of which are in the position of the crew of a large ship, who should depend for their water upon the rain and dew that fell upon the deck, having provided means that the whole of this should run down as it fell into the tanks in the hold.

Venice, once the queen of the Adriatic, still sits, though in mourning and dethroned, upon the site of her ancient glory,—sea-surrounded, in the great salt Lagune,—upon a cluster of islets, many of them artificial,—none better than banks and ancient delta shoals, and until the railway viaduct bridged the westward waters, truly insulated,—for the most part practically so now,—for each islet is cut off from others by the intervening canals.

The city, including numerous small gardens and courts, with its public places, &c., covers an area of 5,200,000 square metres, or nearly 1289 statute acres, exclusive of canals, small and great. In average years there fall 32·3 inches of rain. Almost the whole of what falls over the surface of the city—upon its roofs, gardens, courts, and public places, is collected into no less than 2077 cisterns, of which 177 are public property, the remaining 1900 belonging to private individuals.

The total capacity of all these cisterns united, is seven millions one hundred and sixty thousand six hundred cubic feet.

The rain gauge kept at the Patriarchal Seminary proves that sufficient rain falls, and at intervals, such as to be capable of filling all these cisterns five times per annum. This gives a supply for each of the inhabitants of 5·28 Imperial gallons English per day in gross; but as nearly one-third of the storage capacity of the cisterns is occupied by sand for filtration, we must deduct its bulk, and this reduces the available supply to 3·52 gallons per head per day. This is a very inadequate supply for any climate, but is especially so for a warm one. It is not much more than one-sixth of what British hydraulic engineers have fixed upon as a moderate amount; nor does it reach one-twentieth of the ample volume with which several British and French cities, such as Glasgow and Marseilles, have been artificially supplied.

Venice, however, is exceptional in point of position, and also in dispensing with some demands for water, arising from its position. From the almost total absence of cesspools and sewerage, the canals become the receptacles of all the filth and refuse of the city; there is, therefore, little or no demand for water for flushing, or in any other way in connexion with sewerage. Again, by the habits of the country, most of the washing of clothes is performed upon the open waters of the canals of the Lagune, and but little of the precious fresh water is thus consumed.

The point of greatest interest in the water supply of Venice, however, is found in the admirably simple, and yet perfect construction of the cisterns, or wells as they are called, in which the rain water is collected and preserved. This construction mounts to a remote era; and like the granaries excavated out of the dry cretaceous limestone of Malta,—as is supposed by the knights of Malta, ages ago, and in which grain is even now kept for lengthened periods perfectly good,—these cisterns present a remarkable example of the highest ingenuity, and skilful adaptation by the self-taught engineers of the middle ages, of materials the very simplest and cheapest, combined to attain with perfection the end desired.

Fig. 1.

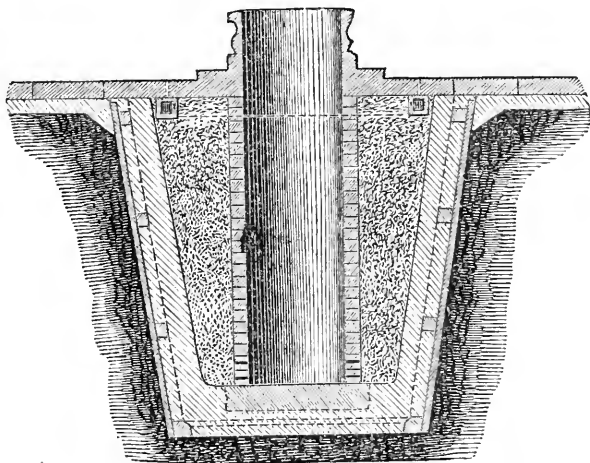
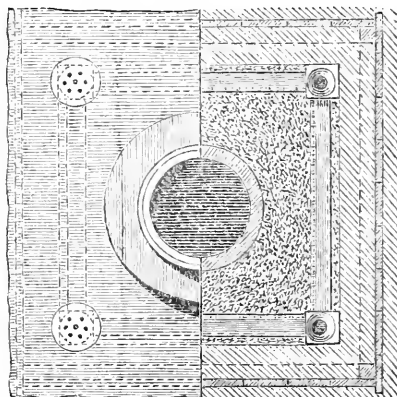
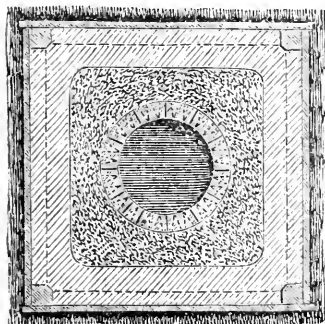


Fig. 1 is a vertical section of one of these cisterns; and figs. 2 and 3 are horizontal sections, showing their construction. They are all

Fig. 3.

Fig. 2.



made upon one established orthodox plan, and have been so for ages. The objects in view in these cisterns were to produce the means of col-

lecting the rain water from roofs and open surfaces, to filter it at once upon its collection, and to pass the filtered water into a storage reservoir, so circumstanced that it should be there preserved pure and cold.

Well-tempered clay, sand, and a little rough timber and some brick work, are almost the whole materials of these structures.

To construct one of these wells, an excavation is made in the soil to the depth of 10 or 12 feet—seldom deeper, for beyond this the infiltration of brackish water from the Lagunes is almost everywhere encountered. The excavation is made in the form of a quadrilateral pyramid, with its base uppermost, and truncated below, the area of the bottom being from one-half to three-fourths that of the base at the surface. The sides are cut down flat and square, and the bottom levelled nicely, and sometimes rammed with a little hard stuff, gravel, &c.

The sides of this pit are now lined throughout by a frame planked on the outside, which is roughly put together, generally with treenails; but the exterior planking is *closely jointed*, and the timber is always sound oak, chestnut, or larch timber. Upon the bottom of the pit is laid in, a thickness of 6 or 8 inches of thoroughly well tempered and very stiffly worked clay, each shovelful being perfectly united and incorporated with the rest, and the whole beaten well together, and levelled down by rammers on top. Upon this is laid in, a large flat stone, like a grindstone without an eye, roughly dressed to a circular form all round, and wrought pretty smooth on the top bed.

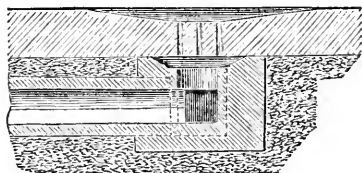
Sometimes these stones are in diameter large, and such as to extend beneath the whole diameter of the cylinder of the well, as shown in figs. 1 and 2; but in other cases, either when large stones have been difficult to procure, or when the diameter of the walls has been made larger than is common (3 to 4 feet being the average diameter), the bottom stone is smaller, and the first courses of bricks are corbelled out over it, course after course all round, until the diameter of the cylinder of the well is gained, so that the bottom of the interior of the well is a sort of inverted cone; this is, however, deemed inferior practice.

Against and upon the inclined surfaces of the timber work, there is now carried up, a thoroughly united bed or wall of well and stiffly tempered clay, well united with the bed of like material beneath the bottom stone, and all round the latter. The utmost care is taken in laying this in, by hand, lump after lump, beating them together, so as not to leave a single crevice or air-hole in the whole mass. Clay of admirable quality, perfectly free from sand or pebbles, is found in abundance, by dredging, in various places about Venice. When this surrounding wall of clay, which is about 12 inches in thickness, has been carried up 3 or 4 feet, the cylinder of the well itself is commenced being built within it, upon the base of the central stone. This is constructed of dry bricks, nicely moulded to the proper form, in curve and radius, and the three or four lowermost courses of bricks are all perforated with holes radially. These holes are not very small, but a few handfuls of gravel or pebbles at the back, prevents anything but water passing through them.

The interspace between this cylindrical brick wall and the clay envelope all round, is now filled in, with sifted and washed sand, of a fineness and quality that experience has decided upon as suitable, which is obtained by dredging from the Adriatic, and thus the work is proceeded with until the surface level is nearly reached. Assuming now that the well is intended to receive its water from the surfaces of the roofs, &c., of a Palazzo, or other building, and from that of the interior court in which the well (*Pozzo*) stands, like the *Impluvium* of old Roman houses; the roof water is discharged into surface channels, cut in the flagging of the central court, and the whole of this surface is laid with a very slight fall to the place of the well.

At the four corners of the square of sand, as seen in fig. 3 (of which one-half is a plan above the level of the flagging, &c., and the other a horizontal section a little way below it, at level c, d,) are laid in four perforated blocks of stone, formed as in enlarged section, fig. 4, (parallel to one face of the square,) called

Fig. 4.



*Cassettoni*. These are all connected by a square of tubes of hollow bricks, made like square drain tiles, and perforated with small holes at the sides, looking towards the centre of the well, or sometimes at both sides. All these are simply bedded into the sand firmly, which has been rammed or compressed together gently, as it has been filled in, and wetted occasionally during the process. Above each of the *Cassettoni*, and bedded down in contact with it, is placed a dish, formed and perforated in a square, of flagging, which forms so much of the surface of the court, and receiving all the water coming from roofs or other areas, transmits it down into the horizontal hollow brick perforated tubes, and these into the body of the sand. From the latter the water finds its way, in through the bricks of the cylinder of the well, which it fills gradually up to the top with filtered water. The well is thus a reservoir surrounded by a body of saturated sand, which drains itself dry, as the water by consumption falls in level.

Many of these wells are like that shown in the figure "Draw wells," with a low circular or polygonal parapet around them above the surface. This is often of marble, or cast in bronze, and adorned with all the storied beauty of high relieved sculpture, in Byzantine or *cinqe cento* style, and unencumbered with any apparatus to draw, but the pitcher and cord; and one often finds beside them such scenes as that so pictorially told in the gospels, of one who at even-tide "sat upon the well," when a Samaritan woman came to draw from it. The water contained in these wells, or cisterns, is always found perfectly fresh, and cool to the palate. Its temperature is, in fact, almost precisely that of the mean temperature of the soil at 10 feet deep, which in Venice is about 52° Fahrenheit, and about the very best for drinking water.

Venice is a city with nearly no soot, and scarcely any dust. Whether wholly from these circumstances, or from others not yet explained, the fact is certain, that these wells continue, without renewal or washing of the sand, to supply water pure and sweet for years, and preserve it cool and fresh to the last drop. In general the demand for water so far exceeds the supply, from the proportion of gathering surface that can be given to these wells, that there is little risk of their overflowing; but the chance of this occurring in one of those semi-tropical rain storms that sometimes pass over this part of Italy, is provided for occasionally by an earthen overflow pipe placed just above the level of the *Cassettoni*, and conducted by an open channel to the nearest outfall. So little are these important, however, that "*una dotta generosa*," a liberal supply, is deemed the highest recommendation by a Venetian, of his well. The grand structural precaution is against the penetration of the wall of puddle or clay, round the sand, by the entrance of the fibrous roots of trees growing in the soil around; these run toward the subterranean water with a sort of instinct that is quite wonderful, and it is against these that the closely-jointed planking is provided mainly. It is said that when this is properly fitted, and the clay laid in without *rigolas* or leakage points, and 12 inches thick, roots are never known to get through; whenever they have been found to do so, their presence is sooner or later found, after they have penetrated into the sand, by their making the water vapid and impure.

It may be a matter of question, and has not, that we know, as yet been matter of experiment, how far this form of filtration, deprives rain water of some or all of its ammoniacal salts, which are the only impurity, of importance, with which rain comes down loaded. Probably no hydraulic engineer, who had a choice of other good sources of supply, would propose to supply a great city, from rain thus caught and instantly entrapped, before it has had time, by surface or subterranean travel, to get fully aerated, and more or less mineralized, although for everything but drinking, no water can be purer or better than this. There are many places, however, in our own and other countries, where the structural idea of these wells of Venice might be advantageously borrowed for adoption. With ourselves in London, for example, where the hardness of our water makes it objectionable for washing, tea making, &c., there are numbers of the better class of houses in the civic parts proper, and still greater numbers throughout the suburbs, now provided with tanks or water butts, or reservoirs of one sort or other, for rain water delivered from their own roofs, but most generally without any filtration whatever; and as our soot-saturated rain drives the washings of the black roofs all away along with itself into these tanks, so the water is never anything but a brown and ugly, bad flavored liquid. It would seem by no means difficult to modify the construction of these Venetian wells, so that a very cheap and excellent form of filter and storage tank, fitted to our particular conditions, might be devised and adopted by our house builders. The external casing might be made at once of slate slabs, and the sand in-

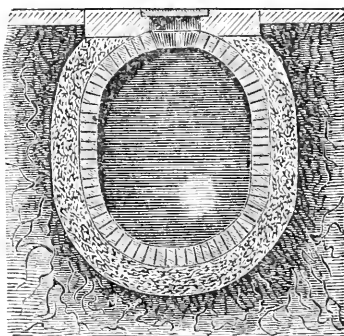
terposed between it and the sides of the brick-lined well, from which the pumps of two or more houses might draw; and it would be very easy to devise means for removal and washing of the sand, for keeping back all the solid grosser particles in the water before it entered the sand, or even for washing clean the latter by a reverse current occasionally, of common water from the water mains.

The writer of the present paper himself constructed a water tank several years ago, upon methods having considerable analogy with those above described.

It consisted of two hemispheres of 12 feet interior diameter, united by a cylinder of about 4 feet high, and of equal diameter, all of but one brick thickness, laid in common mortar, and built (by taking advantage of the *dome* form) without any centering whatever; the whole being surrounded externally by about 15 inches in thickness of well-tempered and hard beaten clay, laid against the soil cut out to the proper form and size. This tank is still in use, and perfectly water tight. It cost an extremely small sum in proportion to its capacity. It was so placed that no trees could come near it; and the greater portion of the clay was so deep as to be out of the reach of worms. It is shown in fig. 5.

The data with which we commenced as to the rainfall and supply of Venice, may be viewed as authenticated, having been derived from Signor Salvadori, the engineer-in-chief to the municipality of Venice. When the railways from Padua and from Treviso were brought into Venice, it was, we believe, intended to have carried in a new water supply also upon the viaduct. We are, however, not aware that this has yet been carried out. The distribution by pipes, in Venice itself, will al-

Fig. 5.



ways be a matter of some engineering difficulty. There is here room for British engineering enterprise, as well as in cleansing the canals from the accumulated putrid silt of ages. So foul is this, and so loaded with phosphorus and sulphur, from the decay of marine animal life and city offal together, that torrents of gas bubbles rise in the wake of every gondola from the bottom, by the slight disturbance of the mud in its passage; and in the twilight gloom of a hot and rapid night in August some years ago, we observed numbers of these gas bubbles, inflame spontaneously, on reaching the surface of the water, in some of the narrower canals of the oldest part of the city, while the water was so loaded with sulphides, that a bright ducat piece lowered down to near the bottom by a string, came up brown after a few minutes immersion. Countless myriads of horrid looking little black crustaceans, fringed the walls at both sides, close to the edge of the water, and rushed up their surfaces, a few inches, as the gondola swept by,

to avoid the ripple that ran along, produced by its passage, and mosquitoes innumerable piped and worried us, in the breathless stench.

It is no wonder that Venice is at all times an unhealthy city, and especially so in the autumn.—ED.

*On the Reconstruction of the Dinting and the Mottram Viaducts.*

By Mr. W. FAIRBAIRN, F.R.S., M. Inst. C.E.

From the London Artizan, April, 1863.

After alluding to the many advantages resulting from the application of a tenacious but flexible material, like wrought iron, either in the tubular girder, or other forms in which it was now employed, as being probably the most suitable for bridges and viaducts of great width and span, where strength and durability were required, the author remarked, that at the present time there did not appear to exist any inducement, on the score of economy, for the introduction of a perishable material, such as timber, into structures intended to be of a permanent character. He then briefly described the original condition of the Dinting and the Mottram viaducts, on the Sheffield and Manchester Railway, which were erected in the year 1843-44, under the direction of the late Mr. Joseph Locke. The former consisted of five arches of 125 feet span, and the latter of one arch of 150 feet and two of 125 feet span, constructed of timber ribs on the laminated principle. As was generally the case with similar structures, within ten or twelve years after their erection, the timber was so much decayed as to endanger their security, and to render considerable repairs indispensable. It was then contemplated to substitute iron work, but this step was not finally determined upon until the year 1858, when the viaducts were again in such a state as to alarm the passengers. It was stated that the restored portions for each viaduct consisted of two longitudinal and continuous tubular iron girders, fixed to the middle piers, and free to expand and contract in the direction of the abutments. To the top of these girders iron cross-beams were riveted, on which were laid the longitudinal sleepers for supporting the rails. There was nothing new in the construction of the girders. They were one-thirteenth of the span in depth, and the areas of the top and bottom flanges were in the proportion of 7 to 6, the breaking weight, equally distributed, amounting to 12·58 tons per lineal foot. The chief novelty was in the mode of erection, and in the method of substituting iron for wood; the Directors of the Railway Company having insisted on the condition that the traffic should not be interrupted during the progress of the works. Several plans were proposed, but that which was ultimately adopted was to construct the girders on the old existing platforms, to cut down the piers and the abutments, and then, by a simple mechanical apparatus, first to suspend and afterwards to lower the girders into their places. A strong wooden frame, about 16 feet high, was erected on the pier at each end of the girder, and on the top of this was inserted a cast iron plate, with a hole in the centre, through which a square-threaded screw  $4\frac{1}{2}$  inches in dia-



meter was passed. Centred on this screw and resting on the cast iron plate was a bevel wheel, which received motion from a pinion in connexion with spur-gearing worked by crank handles in the ordinary manner. On the lower end of the large screw was forged an eye, to receive a cross-bar, having links at each extremity, which hooked under the angle irons at the sides of the girders. With six men at the handles, each girder was raised and lowered into its place in one hour. When one line of girders was thus completed—the whole of the traffic having in the meanwhile been carried by a single road—a temporary way was laid upon this line of girders, and the traffic was transferred to it. The girders on the other side of the viaduct were next constructed, and when they were finished the iron cross-beams were riveted to these girders, and the permanent way for this line was made good. The trains were again passed on to this road, the permanent way on the other side was laid, the timber arches and the framing were removed, and the viaduct was complete.

*Experiments on the Gauging of Water by Triangular Notches.*

By JAMES THOMAS, M. A., Prof. C. E. Queen's Col. Bel.

From the Lond. Civ. Eng. and Arch. Journal, April, 1863.

With reference to the comparison made, in the concluding sentences of the Report, between the quantities of water which for any given depth of flow are discharged by notches of different widths, and to the opinion there expressed that we might, without danger of falling into important error, pass from the experimental determination of the coefficient for a notch so wide as four times its depth, to the employment of notches wider in any degree, by simply increasing the coefficient in the same ratio as the width of the notch for a given depth is increased, I now wish to add an investigation, since made, which confirms that opinion, and extends the determination of the discharge beyond the notches experimented on, to notches of any widths great in proportion to their depths. This investigation is founded on the formula for the flow of water in rectangular notches obtained from elaborate and careful experiments made on a very large scale by Mr. James B. Francis, in his capacity as engineer to the Water-power Corporation at Lowell, Massachusetts, and described in a work by him, entitled "Lowell Hydraulic Experiments," Boston, 1855. That formula, for either the case in which there are no end-contractions of the vein, or for that in which the length of the weir is great in proportion to the depth of the water over its crest, and the flow over a portion of its length not extending to either end is alone considered, is

$$Q_1 = 3.33 L_1 H_1^{\frac{3}{2}} \quad (1)$$

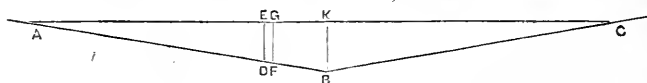
where  $L_1$  = length of the weir over which the water flows, without end-contractions; or length of any part of the weir not extending to the ends, in feet;

$H_1$  = height of the surface-level of the impounded water, measured vertically from the crest of the weir, in feet;

and  $Q_1$  = discharge in cubic feet per second over the length  $L_1$  of the weir.

It is to be understood that, in cases to which this formula is applicable, the weir has a vertical face on the upstream side, terminating at top in a level crest; and the water on leaving the crest is discharged through the air, as if the weir were a vertical thin plate.

To apply this to the case of a very wide triangular notch. Let  $ABC$  be the crest of the notch, and  $AC$  the water level in the impounded pool. Let the slopes of the crest be each  $m$  horizontal to 1 vertical;



or, what is the same, let the cotangent of the inclination of each side of the crest to the horizon be  $=m$ . Let  $AE$ , a variable length,  $=x$ .

Then  $ED = \frac{x}{m}$ . Let  $EG$  be an infinitely small element of the horizontal length or width from  $A$  to  $C$ . Then  $EG$  may be denoted by  $dx$ . Let  $q$  = quantity in cubic feet per second flowing under the length  $x$ , that is, under  $AE$  in the figure. Then  $dq$  will be the quantity discharged per second between  $ED$  and  $GF$ . Then, by the Lowell formula just cited, we have

$$dq = 3.33 dx \left( \frac{x}{m} \right)^{\frac{3}{2}};$$

whence, by integrating, we get

$$q = 3.33 \frac{1}{m^{\frac{3}{2}}} \cdot \frac{2}{5} x^{\frac{5}{2}} + c,$$

in which the constant quantity is to be put  $= 0$ , because when  $x = 0$ ,  $q$  also  $= 0$ . Hence we have

$$q = \frac{2}{5} \times 3.33 \frac{1}{m^{\frac{3}{2}}} x^{\frac{5}{2}}. \quad (2)$$

Let now  $H_2$  = height in feet from the vertex of the notch up to the level surface of the impounded water  $= BK$  in the figure. Then  $AK = m H_2$ . Let also  $Q_2$  = the discharge per second in the whole triangular notch = twice the quantity discharged under  $AK$ . Then, by formula (2), we get

$$Q_2 = \frac{4}{5} \times 3.33 \times \frac{1}{m^{\frac{3}{2}}} (m H_2)^{\frac{5}{2}}; \text{ or}$$

$$Q_2 = 2.664 m H_2^{\frac{5}{2}}. \quad (3)$$

To bring the notation to correspond with that used in the foregoing report, let  $Q$  = the quantity of water in cubic feet per minute, and  $H$  = the height of the water level above the vertex in inches. Then

$$Q_2 = \frac{Q}{60}, \text{ and } H_2 = \frac{H}{12};$$

and, by substitution in (3), we get

$$Q = 3.20 m H^{\frac{5}{2}}. \quad (4)$$

This formula then gives, deduced from the Lowell formula, the flow

in cubic feet per minute through a *very wide notch* in a vertical thin plate, when  $H$  is the height from the vertex of the notch up to the water level in inches, and when the slopes of the notch are each  $m$  horizontal to 1 vertical.

As to the confidence which may be placed in this formula, I think it clear that, for the case in which the notch is so wide, or what is the same, the slopes of its edges are so slight that the water may flow over each infinitely small element of the length of its crest without being sensibly influenced in quantity by lateral contraction arising from the inclination of the edges, the formula may be relied on as having all the accuracy of the Lowell formula from which it has been derived; and I would suppose that when the notch is of such width as to have slopes of about four or five to one, or when it is of any greater width whatever, the deviation from accuracy in consequence of lateral contraction might safely be neglected as being practically unimportant or inappreciable.

This formula for wide notches bears very satisfactorily a comparison with the formulas obtained experimentally for narrower notches, as described in the foregoing report. For slopes of one to one the formula  $Q = \cdot 305 H^{\frac{5}{2}}$ , and for slopes of two to one the formula was  $Q = \cdot 636 H^{\frac{5}{2}}$ . To compare these with the one now deduced for any very slight slopes, we may express them thus:—

For slopes of 1 to 1 . . . . .  $Q = \cdot 305 m H^{\frac{5}{2}}$

And for slopes of 2 to 1 . . . . .  $Q = \cdot 318 m H^{\frac{5}{2}}$

While for any very slight slopes, or for any  
very wide notches, the formula now deduced from the Lowell one is . . . . .  $Q = \cdot 320 m H^{\frac{5}{2}}$

The very slight increase from  $\cdot 318$  to  $\cdot 320$  here shown in passing from the experimental formula for notches with slopes of two to one, to notches wider in any degree—that slight change, too, being in the right direction, as is indicated by the *increase* from  $\cdot 305$  to  $\cdot 318$  in passing from slopes of one to one to slopes of two to one—gives a verification of the concluding remarks in the foregoing report; and this may serve to induce confidence in the application in practice of the formula now offered for wide notches.

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*Structures in the Sea, without Coffor Dams: with a Description of Works of the New Albert Harbors at Greenock.* By D. MILLER.

From the London Artizan, May, 1863.

It was stated that the immediate object of this paper was to treat of the various methods of constructing the foundations of quays, walls, piers, or breakwaters, for the formation of docks and harbors in deep water; and to describe works of this kind which have been carried out on principles different to those usually practised, and to point out the further application of those principles to other structures of a similar nature. The plans which had chiefly prevailed were, founding upon piling carried up to about the level of low water, constructing within

caissons or coffer-dams, or building under water by means of diving apparatus. Instances of the failure of the first of these methods, which was believed to be inapplicable where there were marine worms, were given. The second was most effectual, but was generally expensive, and often attended with danger. The last was also costly, besides being subject to delay in the progress of the works. In bridge building of late years, the plan of forming enclosures of close piling, of the shape of the pier, and filling in with hydraulic concrete, had been pursued by French engineers; and the substitution of iron for perishable timber piling, in the construction on this plan of the piers of the Chelsea and Westminster bridges, by Mr. Page (M. Inst. C. E.), was considered to be a successful departure from stereotyped rules.

Although the value of beton, or hydraulic concrete, was now appreciated in this country as a substitute for masonry, and had been employed in some important works, yet its use was chiefly confined to forming a homogeneous and monolithic bearing stratum for foundations, and not, properly speaking, as a constructive material. The modes in which concrete had been applied for constructive purposes were, building it dry in mass, and allowing it to set before being placed in the work, as had been adopted in the construction of the walls of the Victoria and of the London Docks; preparing it first in blocks, and allowing it to harden before being used as employed at the Dover breakwater, and for the new sea forts at Portsmouth and Plymouth: and depositing it in a liquid state, and allowing it to set under water, as practised at the Government Graving Docks at Toulon. The facilities for making beton, which had the invaluable property of setting under water, and of thus forming an artificial rock or stone, were very great; as it might be made either from the naturally hydraulic limes, the artificially hydraulic limes, or cement, or from the rich or non-hydraulic limes, rendered hydraulic by the admixture of other substances, such as Puzzolana, minion, or iron mine dust. Various examples were adduced of the application of concrete, on a large scale, prepared from these different materials, especially at the Mole of Algiers, at the breakwater at Marseilles, and at other French ports, as well as in the Pont d'Alma over the Seine, in which case both the arches and the piers were formed of rubble concrete.

As Engineers-in-chief for the new harbor works for the port of Greenock, the author and his partner, Mr. Bell, had an opportunity of introducing a system of constructing sea walls and quays in deep water, without the aid of coffer dams, diving apparatus, or other means equally expensive. These works were situated on the west side of the town, and had been projected almost entirely beyond the high water line into the sea. The outer pier would ultimately be upwards of 3000 ft. in length and about 60 feet wide at the top, with quays on both sides. Within this there would be space for two harbors, each 1000 ft. in length, 15 ft. deep at low water, and 25 ft. at high water, with entrances 100 ft. wide, and ample room for the construction of graving docks, for the storage of timber, and for the erection of sheds. At present it was only proposed to erect about one-half of the sea pier,

and to form one harbor or tidal dock. In the design of these works, it was suggested that the walls under low water should consist of a combination of cast iron guide piles in the front, with a continuous stone facing, slid down over and enclosing these piles, timber-bearing piles being used in the body of the walls where required, and concrete backing being deposited in a soft state; and that the upper part of the walls should be built of masonry in the usual manner. The first operation, when the water was not sufficiently deep, was to dredge two parallel trenches to the required depth, 17 feet below low water, for the foundations. A staging of timber piles was afterwards erected in the line of the pier over its whole breadth, for carrying the tramways traveling cranes, and piling engines. The cast iron guide piles were then driven from the staging, with great precision, 7 feet apart in the line of the face of each quay wall. These piles were driven until their heads were near to the low water line, by pile engines, furnished with long arms projecting downwards, strongly stayed by diagonals, and forming a trough, into which the pile was placed, and from which it was shot, like an arrow from a cross-bow. The piles were connected at the top transversely by wrought iron tie-rods stretching through the pier. When the piling was driven, a bed of hydraulic concrete, 3 feet thick and 20 feet wide, was deposited in the trenches to form a base for the wall, and to give a large bearing surface. Into the grooves formed by the flanches of the iron piles, large granite slabs from the Ross of Mull, from 18 inches to 2 feet thick, were slipped, the bottom one resting on the concrete base, and on a projecting web cast on the piles. This constituted the face of the wall, and in each compartment between the piles, 16 feet in height and 7 feet in width, there were only three stones. Behind this facing hydraulic concrete was lowered, under low water, in large boxes having movable bottoms, and was discharged in mass to form the body of the wall. To confine this at the back before it had set, loose rubble stones were deposited. The hearting of the pier consisted of hard till, stones, and granite up to the level of low water. When the whole of this mass was consolidated, the heads of the iron piles and the granite facing blocks were capped by a granite blocking or string-course, and the upper portion of the walls was built in freestone ashlar and rubble. The remainder of the hearting between the walls was then filled in, and the whole finished with a granite coping and causeway. The walls were 33 feet in height from the foundations,  $11\frac{1}{2}$  feet thick at the concrete base, diminished by 5 feet at the top. In the part of the work already executed, the outer flanch of the iron piles was exposed to the action of the salt water. In future it was intended to reverse this plan, and to make grooves in the stone facing, so that it should overlap the iron piles, filling in the grooves from the top with cement. When the whole extent of the seaward pier was completed, the interior operations for the harbor would be proceeded with; this pier serving as the principal coffer dam, and a short dam, about 100 ft. in length, closing the entrance. It was stated that this method of constructing walls in deep water without coffer dams had been most successful, and that a sea-pier of great solidity

and durability had been formed in deep water at a comparatively moderate cost. The works of the Albert Harbor were being executed under the superintendence of Mr. John Thompson, as resident engineer, by Messrs. W. & J. York, contractors.

The application of this system to the construction of breakwaters and harbors of refuge, was then noticed, reference being first made to the principal modes of construction hitherto adopted, and to the peculiar phenomena by which such structures were affected. The usual method of forming breakwaters was by the *pierre perdu*, or long slope system, as carried out at Plymouth, Cherbourg, and Holyhead. Where stone was most abundant, a vertical wall was built from the bottom by means of diving apparatus, of which the breakwater at Dover, now in course of construction, was the most prominent example. Besides these systems, which might be taken as the extremes, an intermediate form of section, combining both, that was to say, a rubble mound to a certain depth under low water, and a vertical wall above, had been carried out at Alderney. From an examination of the general principles which affected breakwaters, and the modes of construction usually adopted, the conclusion arrived at was, that the vertical system was that which had best resisted, or rather averted, the destructive action of the sea, and required the smallest amount of material. Both the long-slope and the vertical systems, as at present carried out, were expensive, from the quantity of material used in the one case, and the costliness of the material and the mode of construction in the other; the former might be characterized as involving the maximum in quantity, and the minimum in cost of material; the latter, on the contrary, the minimum in quantity, and the maximum in cost of material. The object sought to be attained in the new system was to effect a minimum, as far as possible, both in the quantity and in the cost of the material. Breakwaters might be thus constructed, either wholly vertical from the bottom, or partially vertical, springing from a rubble mound. The principal feature of the new plan was a framework of iron piles, or standards, and ties, which would serve during the construction as the staging, and would afterwards form an essential portion of the structure, by binding together a strong casing of stone, or other sufficiently durable material, which would enclose and form the facing of the breakwater, the interior being filled up with loose rubble, cemented into a solid mass by liquid concrete. As soon as a pair of piles transversely had been fixed, rubble would be deposited up to, say, 18 feet under low water. Strong casing blocks, either of stone or of *beton*, made to enclose the iron standards, would then be lowered, the blocks being locked or arched into each other, so as to resist pressure from behind, and made to break bond, if thought desirable. The hearting of the work would be proceeded with simultaneously with the building of the casing, and would consist of rubble in the centre, and of hydraulic concrete behind the stone casing. It was believed that such a structure could be erected in a depth of 6 fathoms, with a range of tide of 15 feet, for £190 per lineal yard, without a parapet, and at £200 per lineal yard, including a parapet. The economy of this sys-

tem would arise from the smallness in quantity and the cheapness of the bulk of the material. It would also possess the advantage of rapid execution, as the mass of the material could be deposited without any tedious operation being necessary over a great length of the work at one time.

The author was of opinion that the system which had been described admitted of being applied for the construction of the works under low water, of marine fortifications, as well as of breakwaters, piers, quay-walls, lighthouses, and other similar structures. He considered that, although the mode of constructing an engineering work must be determined greatly by local circumstances, this system presented the following advantages: great economy, combined with strength and durability; facility and rapidity of execution; and adaptability to situations where the present modes of construction would be inapplicable.

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## MECHANICS, PHYSICS, AND CHEMISTRY.

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For the Journal of the Franklin Institute.

### *Notes of Shipbuilding and the Construction of Machinery in New York and vicinity.*

(Continued from p. 318.)

*The Steamer George Washington.*—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Pusey, Jones & Co., Wilmington, Delaware. Route of service, New York to New Orleans. Owners, H. B. Cromwell & Co., New York.

*Hull.*—Length on deck, 180 ft. Breadth of beam, 39 ft. Depth of hold, 11 ft. Do. to spar-deck, 18 ft. 6 ins. Draft of water, 15 ft. 6 ins. Frames—molded, 13 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, brig. Tonnage, 1256 tons.

*Engines.*—Vertical direct. Diameter of cylinders, 45 ins. Length of stroke of piston, 4 ft. 6 ins.

*Boilers.*—One—tubular—located in hold; does not use blowers. Has water bottom.

*Propeller.*—Diameter, 13 ft. 6 ins. Pitch, 19 ft. Blades, 4. Material, cast iron.

*Remarks.*—This vessel is constructed of white oak, chestnut, &c., and square fastened with copper and treenails. Around her frames, which are filled in solid, iron straps, double and diagonally laid,  $3\frac{1}{2}$  by  $\frac{5}{8}$  inches, extends, making them very secure. There is also a head strap of iron of the same dimensions placed around the head of frames. Under both decks knees are placed; her bunkers are of wood, and she has water-ways on both decks. She is supplied with one independent steam fire and bilge pump, and fitted with bilge injections and bottom valves. She has an independent rudder post, and cabin on deck. The whole construction of the *George Washington* is highly creditable to the skill of Messrs. Roosevelt, Joyce & Co., and gives great satisfaction to her owners.

*The Steamer Mary Powell.*—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co., N. Y. Route of service, New York to Newburgh. Owners, A. L. Anderson & Co.

*Hull*.—Length on deck, 267 ft. Breadth of beam, 25 ft. Depth of hold, 9 ft. Draft of water, 5 ft. 3 ins. Frames—molded, 14 ins.—sided, 4 ins.—apart at centres, 12 ins. Tonnage, 796 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 62 ins. Length of stroke of piston, 12 ft.

*Boilers*.—Two—flued—located on guards, uses blowers to her furnaces. Have water bottoms.

*Paddle Wheels*.—Diameter, 30 ft. Material, iron and wood.

*Remarks*.—This steamer is of white oak, chestnut, &c., and square fastened with iron and treenails. Her bunkers are of wood; she has one independent steam fire and bilge pump, one bilge injection, and two smoke pipes. Upon her promenade deck is a saloon cabin. The *Mary Powell* is an excellent river steamer, quite fast, and very comfortable, and is well liked upon her present route.

*The Steamer Pomona*.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co. Route of service, New York to Staten Island. Owners, North Shore Staten Island Ferry Co.

*Hull*.—Length on deck, 190 ft. Breadth of beam, 27 ft. Depth of hold, 9 ft. Draft of water, 6 ft. Frames—molded, 12 ins.—sided, 8 ins.—apart at centres, 24 ins. Tonnage, 500 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 44 ins. Length of stroke of piston, 10 ft.

*Boilers*.—One—flue—located in hold; uses a blower to her furnaces. Has no water bottom.

*Paddle Wheels*.—Diameter, 26 ft. Material, wood.

*Remarks*.—This steamer is of white oak and chestnut, and cross fastened with composition metal and treenails. Her bunkers are of wood, and she has one smoke pipe. Upon the route of her present service, she has given much satisfaction.

*The Steamer Fah-Kee*.—Hull built by E. F. Williams, Greenpoint, L. I. Machinery constructed by Pusey, Jones & Co., Wilmington, Del. Route of service, New York to Hilton Head, S. C. Owners, Adams' Express Company, New York.

*Hull*.—Length on deck, 175 ft. Breadth of beam, 30 ft. Depth of hold, 10 ft. 6 ins. Do. to spar-deck, 18 ft. Draft of water, 14 ft. 6 ins. Frames—molded, 14 ins.—sided, 9 ins.—apart at centres, 25 ins. Rig, brigantine. Tonnage, 750 tons.

*Engines*.—Vertical direct. Diameter of cylinders, 42 ins. Length of stroke of piston, 3 ft. 6 ins.

*Boilers*.—One—tubular—located in hold; does not use blowers. Has water bottom.

*Propeller*.—Diameter, 11 ft. 6 ins. Pitch, 17 ft. Blades, 4. Material, cast iron.

*Remarks*.—This steamer is built of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are filled in solid under engine, and around them extends iron straps, double and diagonally laid,  $3\frac{1}{2}$  by  $\frac{1}{2}$  inches, also, a head strap of iron, 5 by  $\frac{3}{4}$  inches, extends around the head of frames, making them very secure and of great strength. The model of this vessel is very handsome; her lines are graceful, and betoken speed. She was designed and built for service on the coast of China, but her present owners noting her beauty and admirable cargo-carrying capacity, purchased her to run as a



mail and express steamer to Hilton Head. Her bunkers are of wood; she is coppered, has one independent steam fire and bilge pump, bilge injections, bottom valves or cocks to all openings in bottom, and two bulkheads. Mr. Williams is entitled to much praise for the execution of this beautiful work of marine art.

*The Steamer John Taylor.*—Hull built by Barnard & Giles, Albany, N. Y. Machinery constructed by Jas. McGinnis, New York. Route of service, New York to Albany. Owners, New York and Albany Propeller Line.

*Hull.*—Length on deck, 205 ft. Breadth of beam, 38 ft. Depth of hold, 9 ft. Draft of water, 8 ft. Frames—molded, 15 ins.—sided, 7 ins.—apart at centres, 16 ins. Tonnage, 660 tons.

*Engines.*—Vertical geared. Diameter of cylinder, 36 ins. Length of stroke of piston, 3 ft. 8 ins.

*Boilers.*—Two—return flue—located in hold; use blowers to furnaces. No water bottoms.

*Propeller.*—Diameter, 11 ft. Pitch, 16 ft. Material, cast iron.

*Remarks.*—This vessel is of white oak, &c., and square fastened with galvanized iron. She has hanging knees, one independent steam fire and bilge pump, one bilge injection, bunkers of wood, and two smoke pipes. The *John Taylor* is a good boat, and gives satisfaction to all connected with her.

*The Steamer Escort.*—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed and vessel owned by James Murphy & Co. (Fulton Iron Works), New York.

*Hull.*—Length on deck, 190 ft. Breadth of beam, 27 ft. 9 ins. Depth of hold, 9 ft. 6 ins. Draft of water, 5 ft. 3 ins. Frames—molded, 14 ins.—sided, 9 ins.—apart at centres, 24 ins. Tonnage, 480 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 10 ft.

*Boilers.*—One—tubular—located in hold; does not use blowers.

*Paddle Wheels.*—Diameter, 30 ft. Material, wood.

*Remarks.*—This steamer is built of white oak, &c., and fastened with treenails, &c. She has one independent steam fire and bilge pump, one bilge injection; bunkers of wood, and her water-wheel guards are sponsoned. The *Escort* is well built, and will do excellent service upon whatever route of duty she is placed.

*The Steamer Oriole.*—Hull built by George Greenman & Co., Mystic, Conn. Machinery constructed by C. H. Delameter, New York. In Government service. Owners, George Greenman & Co.

*Hull.*—Length on deck, 125 ft. Breadth of beam, 26 ft. Depth of hold, 7 ft. Draft of water, 6 ft. 6 ins. Frames—molded, 11 ins.—sided, 9 ins.—apart at centres, 24 ins. Rig, schooner. Tonnage, 210 tons.

*Engines.*—Vibrating lever. Diameter of cylinders, 20 ins. Length of stroke of piston, 18 ins.

*Boilers.*—One—tubular—located in hold; uses a blower to furnaces. Has water bottom.

*Propeller.*—Diameter, 4 ft. Pitch, 12 ft. Blades, 4. Material, cast iron.

*Remarks.*—This vessel is of white oak, &c., and square fastened with copper and treenails. Her frames are filled in solid under engines, and they are braced with straps, making them very secure. She is supplied with one independent steam fire and bilge pump, fitted with one bilge injection, and all necessary cocks. Her water-ways are of pine, and she has knees under main deck. In every respect this steamer is well built.

*The Steamer Sze-Chuen.*—Hull built by Lawrence & Foulks, Greenpoint, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. Route of service, coast of China. Owners, P. S. Forbes & Co., New York.

*Hull.*—Length on deck, 210 ft. Breadth of beam, 33 ft. Depth of hold, 11 ft. Do. to spar deck, 18 ft. Draft of water, 11 ft. Frames—molded, 16 ins.—sided, 6 ins.—apart at centres, 26 ins. Rig, brigantine. Tonnage, 1090 tons.

*Engines.*—Vertical beam. Diameter of cylinder, 50 ins. Length of stroke of piston, 6 ft.

*Boilers.*—Two—flue—located in hold; does not use blowers. Have water bottoms.

*Propeller.*—Diameter, 10 ft. 6 ins. Pitch, 21 ft. Blades, 3. Material, cast iron.

*Remarks.*—This steamer is of white oak, chestnut, and hachmetac, and square fastened with copper and treenails. Her frames are strengthened and rendered very secure by iron straps, double and diagonally laid,  $3\frac{1}{2}$  by  $\frac{3}{4}$  inches, running around them. Her model is excellent, and her easy and graceful lines betoken speed. The manner of the construction of this vessel reflects much credit upon her builders, and gives great satisfaction to her owners. She has knees under both spar and main decks, water-ways of pine, bunkers of iron, one smoke pipe, one independent steam fire and bilge pump, one bilge injection, bottom valves to all openings in her bottom, and four ports for receiving and delivering cargoes. It is fair to surmise that the *Sze-Chuen* will be very popular upon the route of her service on the great Yang-tsze River, and thus be the means of spreading still further the names of her enterprising owners.

*The Steamer Excelsior.*—Hull built by F. V. Tucker, Red Hook, L. I. Machinery constructed by H. Esler & Co., Brooklyn, L. I. Route of service, Hudson River. Owners, Howland & Frothingham, New York.

*Hull.*—Length on deck, 190 ft. Breadth of beam, 22 ft. Depth of hold, 10 ft. Draft of water, 8 ft. Frames—molded, 15 ins.—sided, 10 ins.—apart at centres, 25 ins. Tonnage, 410 tons.

*Engines.*—Vertical beam. Diameter of cylinders, 18 ins. Length of stroke of piston, 18 ins.

*Boilers.*—Two—tubular—located in hold; do not use blowers. Have water bottoms.

*Propeller.*—Diameter, 6 ft. Pitch, 13 ft. Material, cast iron.

*Remarks.*—This boat is of white oak, &c., and well fastened. She has one independent steam fire and bilge pump, and one smoke pipe.

*The Steamer Monohassetts.*—Hull built by Thos. Collyer, New York. Machinery constructed by Neptune Iron Works, New York. Route of service, New Bedford to Edgartown. Owners, New Bedford and Edgartown S. B. Company.

*Hull*.—Length on deck, 180 ft. Breadth of beam, 25 ft. Depth of hold, 9 ft. 6 ins. Draft of water, 5 ft. 3 ins. Frames—molded, 13 ins.—sided, 8 ins.—apart at centres, 23 ins. Tonnage 450 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 40 ins. Length of stroke of piston, 10 ft.

*Boilers*.—One—flue—located in hold; uses a blower to furnaces. No water bottom.

*Paddle Wheels*.—Diameter, 27 ft. Material, wood and iron.

*Remarks*.—This steamer is built of white oak, chestnut, &c., and is well fastened in the usual manner. She has one independent steam fire and bilge pump, one bilge injection, one smoke pipe, bunkers of wood, and a saloon cabin on her promenade deck. It is thought that this vessel will meet the requirements of the route between New Bedford and Edgartown, and give general satisfaction.

*The Steamer Morning Star*.—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Allaire Works, New York. Route of service, New York, New Orleans, and Havana. Owners, New York Mail Steamship Company.

*Hull*.—Length of keel, 275 ft. Do, on deck, 286 ft. Breadth of beam, 38 ft. Depth of hold, 15 ft. 3 ins. Do. to spar deck, 23 ft. Draft of water, 14 ft. Frames—molded, 15 ins.—sided, 12 to 15 ins.—apart at centres 30 ins. Tonnage, 2000 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 80 ins. Length of stroke of piston, 12 ft.

*Boilers*.—Two—return tubular—located in hold; uses a blower to furnaces. Have water bottoms.

*Paddle Wheels*.—Diameter, 33 ft. Number of blades, 28. Material, iron.

*Remarks*.—This vessel is of extraordinary strength; her materials of construction being live oak, white oak, haemetac, and locust. Her fastenings are of the most approved character. The frames of this steamer are filled in solid, and secured with iron straps double and diagonally laid,  $3\frac{1}{2}$  by  $\frac{3}{4}$  inches. She has knees under both decks, water-ways of oak and white pine, one independent steam fire and bilge pump, one bilge injection, and bottom valves or cocks to all openings in her bottom. The *Morning Star* is the first of a line of steamships destined to ply between New York and New Orleans, *via* Havana, belonging to the company above named, of which Mr. John Raynor is President. She has very superior accommodations for passengers, all of the state rooms being of large size, and lighted and ventilated in the most perfect manner, while the height between decks gives to the saloons and state rooms an air of comfort and luxury as well as fitness for occupancy in warm climates. There are two hundred and twenty-three berths in the state rooms of the first cabin, and twenty-four berths in the second cabin. The cabins are painted in pure white, relieved with pink and gold. Recently this steamer went on her trial trip, extending to a point some twenty-five miles outside of Sandy Hook, which resulted with complete satisfaction to her owners and builders. So well pleased were the gentlemen accompanying her, that they held a meeting in her main saloon and unanimously passed the following resolutions:

*Resolved*, That the New York Mail Steamship Company are entitled to the thanks of the citizens of New York, for the addition of this splendid steamship to the commercial marine of the metropolis.

*Resolved*, That in this successful trial trip of this magnificent vessel, we see the augury of the success of the enterprise, and we congratulate the owners on the prospect before them.

*Resolved*, That the gratitude, especially of the merchants of New York, is due to Mr. John Raynor, President, and Mr. John Egerton, Vice-President, and Mr. Robert J. Hubbard the Secretary of the Company, and to the Directors thereof, for the efficient and successful establishment of this new line of commercial steamers.

*Resolved*, That in the construction of this vessel in these times, in the breadth and completeness of its arrangements, we recognise the extension of our national prosperity, and the vigor of individual enterprise.

*Resolved*, That the builders of the hull, engines, and all those who furnished the other equipments, have accomplished all that lay in their different departments to render this vessel worthy of the patronage of the traveling community.

*The Steamer Che-Kiang*.—Hull built by Henry Steers, Greenpoint, L. I. Machinery constructed by Morgan Iron Works, New York. Route of service, coast of China. Owners, Russell & Co.

*Hull*.—Length on deck, 260 ft. Breadth of beam, 36 ft. Depth of hold 14 ft. Draft of water, 8 ft. Frames—molded, 15 ins.—sided, 10 ins.—apart at centres, 26 ins. Rig, Brigantine. Tonnage, 1266 tons.

*Engines*.—Vertical beam. Diameter of cylinder, 70 ins. Length of stroke of piston, 11 ft.

*Boilers*.—Two—tubular—located in hold; do not use blowers. Have water bottoms.

*Paddle Wheels*.—Diameter 30 ft. Material, iron.

*Remarks*.—This steamer is of white oak, chestnut, locust, &c., and fastened in the most approved manner. The frames of this vessel are not filled in solid, but they have iron straps, double and diagonally laid,  $4$  by  $\frac{5}{8}$  inches, extending around them, and a head strap of like metal around head of frames,  $6$  by  $\frac{3}{4}$  inches, rendering them very secure. She has one independent steam fire and bilge pump, one bilge injection, one smoke pipe, and knees under main deck. The *Che-Kiang* is of handsome model, and in her every particular she is constructed with the one idea of making her a vessel second to none of her class. I trust that her career on the coast of the Celestial Empire will prove prosperous.

*The Steamer Tillie*.—Hull built by C. S. Bushnell, New Haven, Conn. Machinery constructed by C. H. Delamater, New York. In Government service. Owners, N. L. & J. L. Griswold & Co., New York.

*Hull*.—Length on deck, 146 ft. Breadth of beam, 26 ft. Depth of hold, 9 ft. Do. to spar deck, 16 ft. 6 ins. Draft of water, 10 ft. Frames—molded, 11 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, schooner. Tonnage, 463 tons.

*Engines*.—Horizontal. Diameter of cylinders, 20 ins. Length of stroke of piston, 17 ins.

*Boilers*.—One—tubular—located in hold; does not use blowers. Has water bottom.

*Propeller*.—Diameter, 10 ft. Pitch, 16 ft. Blades, 4. Material,

*Remarks*.—This vessel is built of white oak, chestnut, &c., and square fastened with copper and treenails. Her frames are filled in solid under engine, and have double and diagonally laid iron straps,  $3\frac{1}{2}$  by  $\frac{1}{2}$  inches, running around them. She has an independent steam

fire and bilge pump, one bilge injection, one smoke pipe, and waterways of white pine.

*The Steamer Hamilton.*—Hull built by Webb & Bell, Greenpoint, L. I. Machinery constructed by Henry Esler & Co., Brooklyn, L. I. Route of service, New York to Brooklyn. Owners, Union Ferry Company.

*Hull.*—Length on deck, 160 ft. Breadth of beam, 32 ft. Depth of hold, 12 ft. 6 ins. Draft of water, 6 ft. 6 ins. Frames—molded, 13 ins.—sided, 6 ins.—apart at centres, 23 ins. Tonnage, 509 tons.

*Engines.*—Inclined. Diameter of cylinder, 38 ins. Length of stroke of piston, 10 ft. *Boilers.*—One—flue—located in hold; does not use blowers. No water bottom.

*Paddle Wheels.*—Diameter, 16 ft. Material, wood and iron.

*Remarks.*—This vessel is of white oak, &c., and fastened in the securest manner. It is filled in solid at both ends, the peculiar service of the boats belonging to this company demanding vessels of this character.

*The Steamboat La Bonita.*—Hull built by H. L. Bushe, Greenpoint, L. I. Machinery constructed by Fulton Iron Works, New York. Superintendent of construction, Chas. H. Haswell, New York. Route of service, Guatemala, C. A. Owners, Guatemala Company.

*Hull.*—Length on deck, 42 ft. Breadth of beam, 9 ft. Depth of hold, 2 ft. 11 ins. Draft of water, 12 ins. Tonnage,  $9\frac{5}{8}$  tons.

*Engine.*—Inclined. Diameter of cylinders, 8 ins. Length of stroke of piston 12 ins.

*Boiler.*—One—tubular.

*Paddle-Wheels.*—Diameter, 7 ft. 10 ins. Material, iron.

*Remarks.*—This marine dwarf is of corrugated iron,  $\frac{1}{8}$ th of an inch in thickness, well fastened and admirably put together. Her boiler is furnished with all the gauges, &c., necessary to make it complete. She is supplied with an independent steam fire and bilge pump.

The construction of this vessel is an initiatory step in an enterprise believed to be pregnant with profitable return, not only to her originators, but all connected with her in her future career. She is intended as the pioneer vessel of the Guatemala Company, an association of wealth and enterprise formed in New York, having for its ultimate design, the opening of an extensive trade in the province of Guatemala, Central America, consisting in the cutting and shipping to the United States of pitch-pine timber, forests of which exist there. That this business may be prosecuted with its deserved success, the Directors of the Company have organized an efficient body of operators, and appointed as their general director and superintendent, a Mr. J. A. DeBrame, a gentleman of ability, and one possessing the necessary administrative ability, it is believed for such a position. Mr. De Brame recently left New York with his men and the little steamboat for the scene of their future labors. They went well provided with the engines, saw-mills, tools, &c., requisite for the various manipulations to be gone through with, before their article of trade is ready for shipment and market. I trust that success will attend this movement of the Guatemala Company, and that in the end they will be richly repaid for the energy they have in this wise made manifest.

On the trial trip of the *La Bonita*, her boiler worked well, making ample steam, and she was worked up to thirty revolutions per minute, making some  $7\frac{1}{2}$  knots per hour. This trip satisfactorily proved that even such a little steamer could be built, and worked successfully. B.

New York, May 13th, 1863.

### *The Trisection of an Angle.* By JOHN O'DONOGHUE.

To the Editor of the Journal of the Franklin Institute.

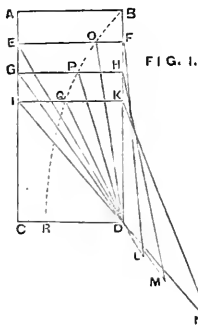
I beg to offer you the following remarks on the trisection of an angle :

This problem, simple as it may appear to be, has engaged the attention of the greatest mathematicians that ever existed. After a long and laborious investigation, Sir Isaac Newton, among the rest, so completely failed in his attempt to solve it on pure geometrical principles, that he declared it impossible for any person to trisect an angle within the limits of pure geometry. It certainly is a most difficult problem, and involves a cubic equation. Hence it requires conic sections and the higher order of mathematics for its solution, if we confine ourselves to the three postulates laid down by Euclid as the basis of all geometry.

Yet simple as these postulates are, still in drawing lines and describing circles we bring to our aid mechanical instruments, such as the ruler and divider. Now, if I am allowed to add another mechanical contrivance to these, with which to describe a curve, I can easily trisect an angle. I see no reason why I should be denied this privilege, when I find such men as Legendre, Davies, and a host of others, not only adding to the number of Euclid's postulates, but changing the order of his books, and not strictly adhering to his propositions.

In order to explain the use of this instrument which I desire to add to the ruler and divider in trisecting an angle, let us premise the following :

Let  $ABDC$  be a rectangular parallelogram, having the side  $DB$  double of the side  $CD$  or  $AB$ . Trisect  $CD$ , and let  $DR$  be double of  $CR$ . Now, I want to describe a curve (fig. 1) passing through the points  $R$  and  $B$ , and having this property, that a line drawn from the point  $D$  to any point in the curve shall be double the perpendicular let fall from that point on the line  $AC$ .



Take any number of points,  $E, G, I$ , &c., infinitely near one another in  $AC$ , and through these points draw the lines  $EF, GH, IK$ , &c., parallel to  $AB$  or  $CD$ , meeting  $BD$  in  $F, H$ , and  $K$ . Join also  $ED, GD, ID$ , &c. Take also the distance  $BD$  in your dividers, and from the points  $F, H, K$ , &c., as centres, describe arcs cutting  $ED, GD, ID$ , &c., produced in  $L, M, N$ , &c.;

hence  $FL, HM, KN$ , &c., are each equal  $BD$ , and therefore doubles of  $FE, GH, IK$ , &c. Through  $D$  now draw the lines  $DO, DP, DQ$ , &c., respectively parallel to  $FL, HM, KN$ , &c.

By similar triangles we have now FL : FE :: DO : OE; but FL is twice FE, therefore DO is double OE. In the same manner it can be proved that DP is double PG, DQ double QI, &c. Now, through the points B, O, P, Q, R, &c., draw the curve BOPQR, and this curve will be such that a line drawn from its focus D to any point in the curve will be double the perpendicular let fall from that point on the line AC.

Now, this method of tracing curves by finding several points in the periphery, and of afterwards connecting them so as to preserve the regularity of the form of the curve, is more a mechanical than a geometrical method of describing them. Hence, to avoid this objection, we make use of the following contrivance for constructing this same curve. It is, I consider, as purely elementary as a pair of dividers are, and no person objects to the use of these in describing circles. Seeing no reason then why a curve described by a pair of dividers should be considered elementary and purely geometrical, while curves described by other instruments are not accepted as such, I have therefore no hesitation in pronouncing the following curve as purely geometrical as the circle is.

Let D be the focus of the curve, R its vertex, join RD, and produce it to C, making CR equal to one-half of RD, and erect CA perpendicular to CD.

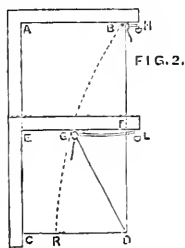
Now take a carpenter's square, and place one of its sides on AC (fig. 2), the other side will fall in the direction AB perpendicular to AC. Again, tie one end of a thread to one side of the eye of a needle, and run the thread (after passing it round a small pin or roller fixed in the side AB of the square) through the eye itself.

Then, after making the whole length of the thread equal to twice  $HA$ , or making the part  $DB$  of the thread equal to twice  $AB$ , fasten the other end in the point  $D$ . Now move the square, sliding the side  $AC$  along the line  $AC$ , and keeping the needle upright and close to the side  $AB$  of the square. The eye end of the needle, while the side  $AB$  of the square moves from the position  $AB$  to the position  $CD$ , will describe the curve  $BGR$  (supposing the thread to wind freely over the pin or roller and the needle kept close to the side of the square during the operation), having this property.

A line drawn from the focus to any point in the curve will be double the perpendicular let fall from that point on the line ac.

This is evident from the construction and the figure. But perhaps the following observations will make it plainer. The whole length of the thread was made equal to twice HA, but that part of the thread from the eye of the needle winding round the pin and back to the eye again is just twice HB; therefore the remainder DB of the thread is equal to twice BA, the perpendicular let fall from the point B on AC.

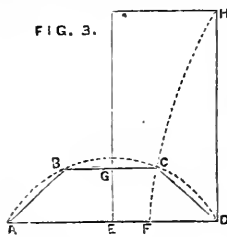
Again, when the side AB of the square comes to the position EL, then the whole thread will be double of LE; but that portion of the thread from the eye G to the pin L being doubled, is twice GL, therefore the remainder DG is also double the remainder EG. Q. E. D.



To apply this curve to the trisection of an angle.

Let  $ABCD$  (fig. 3) be any arc of a circle, and let  $AD$  be its chord; bisect  $AD$  in  $E$ , and from  $E$  erect  $EG$  perpendicular to  $AD$ ; then  $EG$  if produced would pass through the centre of the arc. Trisect the line  $ED$  in  $F$ , and then  $DF$  is equal twice  $FE$ . From  $D$  as a focus and  $F$  as a vertex, describe the curve  $FCH$  by either of the above methods, cutting the arc  $ABCD$  in  $C$ ; from  $C$  let fall the perpendicular  $CG$ , and produce it to meet the arc  $ABCD$  again in  $B$ . I say the arc  $ABCD$  is trisected in  $C$  and  $B$ .

FIG. 3.



Join  $DC$  and  $AB$ . Now, because  $CB$  and  $DA$  are both perpendicular to  $EG$ , they are parallel to one another. Again, as  $BC$  and  $DA$  are two parallel chords, the chords  $AB$  and  $CD$  joining their adjacent extremities are equal. And because  $EG$  passing through the centre cuts  $CB$  at right angles,  $CB$  is bisected in  $G$ . Hence,  $BC$  is double of  $CG$ . But by the properties of the curve,  $DC$  is double of  $CG$ , for the line drawn from the focus  $D$  to any point  $C$  in the curve is double the perpendicular let fall from that point on the line  $EG$ . Therefore  $BC$  and  $DC$  being each double of  $CG$  are equal. But I proved  $DC$  to be equal to  $AB$ . Hence the three chords  $DC$ ,  $CB$ , and  $AB$  are all equal, and therefore the three arcs  $DC$ ,  $CB$ , and  $BA$  are also equal. And as equal angles stand on equal arcs, the whole angle at the centre will be trisected by lines joining the centre to the points  $B$  and  $C$  in the circumference.

Should this be not considered strictly geometrical, still its publication will enable the mechanic and engineer to trisect an angle with mathematical accuracy in a simple and practical manner.

Though others have trisected an angle before now, yet they did not pretend to have done it within the limits of geometry, but made use of conic sections and the higher order of mathematics.

Therefore I think my mode of handling this problem new, and my solution purely geometrical. At all events, my manner of treating it is simple and easily understood, and if allowed the same latitude that some writers on geometry are, I have no doubt of having succeeded. I will be at all times ready to remove any objections that may be raised against it, and receive the criticisms of any geometer as a personal favor.

We publish the above article on account of its ingenuity and because it bears unmistakable evidence of original thought. But the writer is mistaken in thinking that he has avoided Conic Sections, for his curve is a hyperbola, and the trisection of an angle by means of the hyperbola was demonstrated by Pappus, although in an entirely different manner. (See *Montucla, Quadrature du Cercle*, p. 243.) It may also be worth while to protest that Newton's assertion that an angle could not be trisected except by the uses of curves of the higher orders, was founded not only on his failures to solve the problem otherwise, but on a mathematical demonstration of the impossibility.

EDITOR.



*On a Plea for Cotton and for Industry.* Lecture by THOMAS  
BAZLEY, Esq., M. P.

[Before the Royal Institution of Great Britain, May, 30, 1862.]

From Newton's London Journal, September, 1862.

The fact of the cotton trade in this country being dependent chiefly upon one source of supply for its raw material, has been at all times the cause of anxious solicitude to the thoughtful observer of the nation's progress; but the dilemma in which that great industry is now placed by that sole dependence deserves the consideration alike of the statesman, of the economist, of the merchant, of the employers of labor, and of the humane and patriotic public. Between cotton and labor, there was formed in Lancashire, three-quarters of a century ago, an alliance which, combining mechanical with manufacturing skill, has created an industry unparalleled in any other country.

Little more than a century since, the clothing comforts of the masses of the people were few in this country, and the abundant luxuries which now prevail were to them almost unknown. The prepared skins of animals were, up to that recent date, largely used in the clothing of the peasant, and in every house and hamlet the distaff and spindle, and the weaving loom, ministered to the supply of linens, woolens, and their mixture, in aid of domestic wants. In the reign of Elizabeth, her subjects were only equal in number to the inhabitants of Lancashire and Yorkshire at the present time, and greatly below the people of those two counties, with Cheshire added. The British people under Elizabeth were powerful, and in splendor and position ranked with the highest nations of the earth; yet her army, navy, aristocracy, court, and people, did not exceed that portion of Queen Victoria's subjects, who directly and indirectly subsist upon the toils, industry, and capital of the cotton trade. The kingdoms of Belgium, Portugal, Holland, and Hanover do not separately contain populations as extensive as the cotton trade supports in Great Britain; hence this industry of five millions of dependents, sustained by no separate regal power, and hitherto happy and prosperous as a portion of the subjects of our gracious Sovereign, may claim to be at least of some national importance. About three centuries ago, the whole people of this country might be equal to the five millions who now subsist by the manipulations, products, and commerce of cotton; but at this moment the population of the United Kingdom may be regarded as thirty millions, yet the same circumscribed and limited extent of land only exists to afford them the means of labor, and to yield them its fruits which supported their predecessors. Even in Elizabeth's reign, the people were deemed to be too numerous for the extent of land in her British dominions, and restrictions upon the building of dwellings in proportion to the areas of districts were enacted. If, therefore, the augmentation within the period now mentioned, of from five to thirty millions of people, be considered, it is self-evident that new sources of industry have had to be developed to supply increasing wants.

Mineral and agricultural products, in past ages, furnished scanty exports to pay for foreign articles of necessity and luxury; but, with a constantly increasing population, the yield of the soil has been absorbed by the large consumption at home; and now foreign supplies of corn, of other food, and of luxuries, are required for, and may be equal to the subsistence of one-third of the entire population of the United Kingdom. But whilst supplies of food have been needed for this increasing population, the other concomitants of comfort have also been required, and all these necessities of life could only be obtained in this country by the magic power of skill and labor.

A sea-girt land with navigable rivers, thus possessing egress and ingress, seems to invite foreign intercourse, and to be the first essential to a great mercantile and manufacturing district; but when such a country is found to be immeasurably rich in its mines of coals and metals, when it possesses a temperate and healthy clime, and, above all, when its inhabitants are hardy, sagacious, toil-loving, free, and untiring, we may infer that the decree of Providence has ordained that the people with these advantages shall be blest with plenty, and shall contribute of their abundance to the families of mankind. To no country, however, has exclusive advantages been given; but, wisely, mutual dependence appears to be the pacific bond intended to promote the welfare of the common brotherhood. Probably beyond every other people, the British possess the elements of successful trading and commercial industry; but beyond the direct necessities of life, which their labor ought to enable them to buy, they need raw materials whereon that labor can be employed. Sheep's wool and flax, Great Britain can, in part, produce towards the demand for them; but still large quantities of them are required from foreign countries, and silk, cotton, and other productions of the warmer regions must always be imported as contributions in aid of the manufacturing industry of the United Kingdom. Textile fabrics afford in their production the most extensive means of employment, and have become the indispensable clothing comforts of the people of every country. The fabrics and manufactures of cotton are, however, among the most useful, convenient, elegant, and economical productions of labor. From the quilt or bed-cover to the finest and most filmy muslins—from the fustian garments of the poor to the decorations of lace worn by the rich—and in the snow-white gift of the bleacher to the rainbow colors of the printer—cotton is prolific of comfort and ornament.

The persecutions of the Duke of Alva had banished from their homes the Flemish weavers, who took refuge in Britain. These skillful and ingenious workmen became valuable acquisitions in a country commencing the transition from the labors of the field to those of the loom; and the domestic manufactures of our country began to indicate the progress and perfection which they were destined to attain. The dawn of a great industry was perceptible. Industry was honored, and labor inculcated as the foundation of the nation's coming distinction and prosperity. Even more than two centuries ago, when steam engines were unknown, canals not having been formed, nor large manu-

facturing establishments erected, and while deer-forests surrounded this vast city, there were merchants who promulgated sound economical principles, and who taught lessons of wisdom to the possessors of regal power. In London, in 1641, Roberts, a son of commerce, published an enlightened pamphlet, entitled "*Treasures of Traffic*," and in proof of the soundness of his views, the following extract cannot fail of being interesting and welcome. He said,—“Some princes are not satisfied with those materials that grow among themselves, and in their own countries, but they covet by all industry to draw others from their neighbors, or foreign nations, to employ their subjects, and to put their people on work, by this means much enriching themselves, and honoring their country; and adding a great help to the public traffic thereof, selling and venting them thus wrought, even to those nations who many times have sold and furnished them with the very first materials of the said manufactories.” “Manchester in Lancashire, must also herein be remembered, and worthily, and for their industry commended, who buy yarn of the Irish in great quantity, and weaving it, return the same again in linen, to Ireland to sell. Neither doth the industry rest here, for they buy cotton wool in London, that comes first from Cyprus and Smyrna, and at home work the same, and perfect it into fustians, vermilion, dimities, and such other stuffs, and then return it to London, where the same is vented and sold, and not seldom sent to foreign ports.” Thus at a period in English history when Charles the First was surrounded with troubles, discord and distress prevailing, Roberts, in beautiful simplicity of language, uttered the first plea for cotton and for its industry, thereby throwing a lustre upon his own name and upon the seventeenth century.

In the middle of the eighteenth century, a considerable home manufacture had arisen. Cotton was spun by hand, and afterwards blended in the loom with linen or woollen, thus producing a mixed fabric. The supply of cotton was then inconsiderable, and was obtained from Turkey and the Levant, and from the West Indies. Mechanical science now escaped from the libraries and traditions of the learned, and offered practical aid to the infant industry. Such a galaxy of talent and inventive genius as then stood forth to develop new methods of increasing the comforts both of the palace and of the cottage, the world had not seen. By an almost mysterious combination of efforts, Hargreaves, Whyatt, Arkwright, and Crompton were devising their several systems of spinning cotton; Watt was rendering available the majestic power of vapor, directing, controlling, and dooming it to become the universal drudge of man; Scheele and Berthollet, with their oxygenated muriatic acid, blanched the calico and the cambric; and the Mauvillions, Nixons, and Peels gave their colored tints to print these new fabrics; and as if inspired by the inventions which sprang from the east of the Atlantic, the Anglo-Saxon in the United States of America originated the cultivation of cotton in that great territory: but in giving this boon, by the production of slave labor, he conferred the bane whence the vast cotton industry now suffers, in the deprivations inflicted upon labor and capital. In the year 1700, when me-

chanical appliances were comparatively unknown in the manufacture of cotton, the consumption of this material might be one million pounds weight ; but in 1860, the quantity had culminated in the consumption of one thousand millions pounds weight in that year. Cotton began to arrive from America in 1787, in sufficient quantity to prove the power of the States to produce it, and in that year Crompton triumphed over his mechanical difficulties and completed the mule,—this machine being the great agent at the present time for the production of coarse as well as of fine yarns ; but spinning by rollers, and Arkwright's throstle spinning frame, had been invented twenty years previously ; hence the history of the modern and mechanical cotton trade may be dated from this period.

Eighty years ago the cotton industry of our country was thus initiated, and from that time to the present, progress, improvements, and extension have characterized it. The science, skill, and invention which have accompanied its development are wonderful. It has afforded employment, comfort, and prosperity to many millions of the people of this country during that period, and it has contributed very largely to the national revenue. During the great struggle with the first Napoleon, our men were able to leave their country for the strife of war, and yet the steam engine and the mechanical agencies which existed at home more than compensated for their physical loss ; but here was the waste of the nation's strength. Wiser would it have been had these new resources been developed for the moral, mental, and social improvement and comfort of the people at large. Most probably the cotton trade and the development of new mechanical powers, have enabled the people of this country to sustain a system of taxation which, without that trade and those treasures, could not have been borne, and have supported a national expenditure alike extravagant and injurious. The state, therefore, has participated in the contributions of all who have promoted and sustained this industrial fabric.

The capitalists of this trade have now two hundred million pounds sterling invested in it, in fixed and floating property ; and the people directly and indirectly employed in it being now five millions, we arrive at the important deduction that not only does the national exchequer derive great benefit from it, but we have capitalists and laborers supported by it as numerous as are the people of several European kingdoms of the present time. Indifferent spectators of the abundance which has happily prevailed in this country since the introduction of the liberal commercial policy which is now established, rarely reflect upon the obligations this vast industry has conferred in aid of the elements of social comfort. Of late years, the exports in cotton manufactures have been about fifty millions sterling per annum, or about one-third of the gross exports of the United Kingdom. Well, then, as cotton exports constitute one-third of the whole, it becomes evident that cotton buys one-third of the imports ; hence, as gold, silver, gems, coffee, tea, sugar, tobacco, wine, oil, and the fruits of sunny climes, as well as corn and other food brought hither, are foreign products largely imported into the United Kingdom, we must claim the

merit for the cotton trade of having bought and paid for one-third of these exotic and foreign supplies. In 1860, the last year of active and full employment for the whole of the cotton trade, its manufactured products exceeded eighty millions sterling in value, something more than fifty of which were exported, leaving about thirty millions as the value of the home consumption of cotton manufactures; but as this latter sum will about equal the cost of the raw cotton imported, the beneficial interest of the country in the cotton industry will be represented by its export trade of upwards of fifty millions sterling. That so extensive and prosperous an industry should have been founded upon the supply of a foreign product, is not the least wonderful fact of its history; but that cotton should have been almost exclusively, as it has been, obtained from almost adverse sources, is a great reproach to the British nation.

Of the 2,523,000 bags of cotton consumed in this country in the year 1860, 85 per cent. consisted of the growth of the United States, 8 per cent. of the growth of Egypt, Brazil, and other foreign districts; whilst of cotton from the British East and West Indies the consumption was only 7 per cent. ! In consequence of the convulsion in the States of America, the consumption of cotton in Great Britain, in 1861, resulting from its contracted supply and the loss of the American markets for its manufactured products, diminished 10 per cent. ; and whilst of American and other foreign cotton the consumption became only 85 per cent. against 93 per cent. in the previous year, the consumption of East Indian cotton was 15 per cent. against the previous 7 per cent.; but of the present diminished consumption probably 75 per cent. may be East Indian. A very rapid increase has been effected in the consumption of East India cotton, which, in 1860, was 3500 bags per week, in 1861, 7000 bags, and in this year is proceeding at the rate of 15,000 bags, or more, per week, showing the increase to be 100 per cent. per annum upon each successive year. The actual power of consuming cotton in the United Kingdom is 55,000 bags per week; but, lacking the requisite supply, the present total consumption cannot exceed 25,00 bags per week.

Such, then, having been the rise, progress, productive and consuming power of the cotton trade, are we blameless for allowing this immense industry to exist and extend upon the frail basis of slavery upon which it has largely depended?

How fearful is the contemplation of a people, whose labors, directed by intelligence and right principles, having supported them with abundance, and still able and willing to work, being deprived of the material on which their industry has been advantageously engaged? The deprivations in this great industry have become lamentably severe. With less than half a supply of raw material, and at the enhanced cost of a whole supply, only half employment can be afforded, and consequently only half wages, or less, can be earned. Already the working classes of the cotton trade are subjected to diminished earnings of a million pounds sterling per month. Generally, the mills are working half-time, but many are wholly stopped, whilst a very few con-

tinue to give full employment, but the average time now worked will be the half-time now stated; and the consumption of cotton is only 25,000 bags weekly instead of the 55,000 bags capable of being consumed; but in this latter quantity is included the probable consumption of many new mills which have not begun to work. Of the consumption of cotton at the present moment, the East Indies supply 75 per cent.,  $12\frac{1}{2}$  per cent. is America, and  $12\frac{1}{2}$  per cent. other foreign kinds. Last year the East Indies were exhausted of the stocks of cotton usually held there, and it is doubtful whether the million bales then received can be repeated this year. No efforts to obtain cotton from new fields, commensurate with the necessity, are being made.

In 1848 Mr. Bright, M. P. for Birmingham, proved by his parliamentary committee the capability of the East Indies to grow and supply abundantly most excellent cotton. With many men of experience, I gave evidence before that committee; but apathy in the Government, in the trade, and in the public mind, has caused to be neglected the admonitory facts then elicited.

Essentially, Great Britain possesses the monopoly of the best land found in the world for the growth of cotton. In the East Indies, the policy, under the rule of a nominally commercial company, has been absurdly political and despotic. The material prosperity of the people was neglected; navigation, by improving the rivers, has been discouraged; few canals have been formed; roads have scarcely existed; ample means for irrigation have been withheld; quays are almost unknown; and the land held by Government feudal power has been largely unproductive. By the small water supplies of Colonel Sir Arthur Cotton, immense benefits have been derived in Madras, and by the recent changes in land tenure, great improvements will doubtless result. Railways are now being established, and the general indications of the great dependency are becoming favorable for the extension of cotton and other agriculture, and for trade and commerce. For many years the improved navigation of the Godavery has been a subject of contention and of hope deferred. This river ought to connect the great cotton-fields of Berar with Coringa and other ports in Madras. The rocky barriers of the Godavery should be either removed, or they should be avoided by the aid of short links of canals, or by tramways. To what extent the works of the Godavery have proceeded we are ignorant, but the advantages which would accrue from their completion cannot be overstated. Its fertile valley would yield immense supplies of excellent cotton and other products; the markets to ten or twelve millions of people being opened would yield double advantages, alike to a home and a foreign trade. On the banks of that river, at Ingelhaut, cotton of most acceptable quality to the British spinner is already grown; and in its vicinity, as also in Berar, cottons could be cultivated which would equal, if they did not surpass, the productions of New Orleans. Of the power of the East Indies to produce superabundant supplies of most excellent cotton, no doubt need be entertained. The communications within the vast dependency being effectively extended to its sea-board in every direction, its agriculture

being industriously conducted by the aid of practical science, and the government of it becoming wise and just, benefits would flow from and to it, fructifying and enriching the whole empire. In 1860, the imports of cotton from the East Indies were 561,200 bags, of which two-thirds were exported, and in 1861 there came 986,600 bags, or nearly double the previous year's supply; but though the importers of this enlarged import have derived very great profits by the advance which has taken place in the price of cotton, the ryot, or farmer, in India, has not yet importantly obtained any advantage from the increased value of his produce; but if the communication with the interior of India, both as to intelligence and the conveyance of cotton, be facilitated, then the ryot will be stimulated by compensating and increased rewards, to extend the cultivation of cotton, and to improve the quality of it. As now stated, ample proof exists that India can grow most excellent cotton, and many supplies of very useful qualities have been thence received; and I now have the satisfaction of placing before this meeting a sample of superior cotton sent by Dr. Short, from Chingleput, in Madras. I am also enabled to display some very good yarns, of above the average fineness, being 60s. warp and 80s. weft, spun from it by Mr. Kirkpatrick, at his mills near Manchester.

A Cotton Supply Association was formed in Manchester a few years ago, and its labors are constantly directed to obtain corrective measures for the evils of India, and to promote the growth of cotton wherever the soil and climate of any country will enable it to be produced. This association has impelled a wiser policy for India, and has rendered valuable services to that dependency and to other countries; having made grants to upwards of 400 places of cotton seeds and or cleaning gins, besides other agricultural implements. By the exertions of this body, small supplies of cotton have been received from many new fields of cultivation. Cotton-growing is being slowly resumed in the British West Indies, whence encouraging supplies are now received; but if the proprietors of estates in those islands did their duty to themselves and to their country, an enlarged production of excellent cotton would compensate them and contribute to the nation's prosperity. The fine island of Jamaica, which could produce very large quantities of superior cotton, is a territorial wreck; but see the capability of this island by this sample of cloth made from its cotton. Demerara, and other neighboring possessions, can produce more cotton than the United Kingdom could manufacture. From the Cape of Good Hope to Port Natal cotton can be abundantly produced. Africa has of late years sent small, but valuable supplies of cotton, of qualities quite equal to the produce of New Orleans; but her Egyptian cotton has, from the time of Mehemet Ali to the present moment, been a large and most welcome contribution. If the million per annum, which our fleet for the suppression of slavery costs, had been devoted in our own colonies, or even in Africa, to the encouragement of the growth of cotton, sugar, and other products, which the labor of the negro in slavery has yielded, then that disgraceful traffic in human beings might have been annihi-

lated, and our own pursuits untainted with the wrongs inflicted upon the colored race. Australia, however, has amazing powers for the production of cotton, and in sections of that great country—Queensland, Victoria, and New South Wales—cotton of every class, from the lowest to the highest, might be cultivated and produced beyond the wants of all the world. Queensland has sent small lots of cotton of unsurpassed beauty and excellence, and from this colony, and from New South Wales, samples of cotton may be seen in the great International Exhibition of qualities adapted to the production of the finest muslins and laces which any skill could manipulate, as may be seen by this beautiful specimen of lace made from it. Labor appears to be almost alone the sole requisite for obtaining supplies of cotton of incalculable extent from Australia. On referring to the cultivation of cotton in America, we learn that there one million of negroes can produce cotton of nearly twice the extent of its consumption in Great Britain, consequently half a million of laborers would suffice to produce the cotton needed by the latter; and the question arises whether it would not be an act of prudence and of wisdom to induce this number of Chinese men, women, and children to become cotton-growing laborers in Australia. In the States of America, only about one-quarter of the negro population is there engaged in cotton agriculture, the large majority being employed in producing tobacco, rice, sugar, Indian corn, and in handicraft and domestic pursuits or occupations. The Emperor of France has wisely offered great inducements for the growth of cotton in Algiers, whence very superior cotton is already supplied. That French colony is within a single week's sail of this country, and some eminent men of business here and in France are endeavoring to extend the cultivation of cotton in it, which, if judiciously carried out, cannot fail to become of vast advantage to all the relations of both countries.

With these facts, the power abundantly to produce cotton, not only in British possessions, but in many foreign states, is beyond all doubt.

By the general neglect of cotton agriculture, an aggregation of evils now exists which can only be contemplated with profound grief and apprehension. Probably 100,000 laborers, who have usually shared the employment afforded in the cotton trade, are now totally idle and penniless. 300,000 more are working short time, and in the sympathetic branches much deprivation prevails. The losses of the laboring classes are one million pounds sterling per month, or twelve millions per annum; whilst the employing classes are, by loss of rents, interest of money on stagnant capital, and in suspended operations, without computing anything for loss of profit, sustaining a loss equal to eight millions per annum, thus making the certain loss in labor and capital, into twenty millions sterling per annum; but the great infliction of double price for cotton, which adds eighteen millions per annum to its normal market cost, subjects the trade to a drain of nearly forty millions per annum, and to an exhaustion tending almost to extermination. Cotton-spinning and manufacturing in Great Britain, are equal in extent to those pursuits carried on in America, and upon the continent of Europe. Consequently, in the British and foreign cotton



trades, the losses and disadvantages will be double the extent stated for this country alone. A plea, then, for cotton and for industry becomes a duty and a necessity.

Seeing, therefore, the extent of distress existing in the districts of the cotton manufacture, and that increased deprivations may inflict deeper misery upon the laboring classes, whilst many capitalists may be on the verge of total ruin, and seeing also that the people of the United Kingdom generally sympathize with the sufferings in the cotton trade, what assistance can be rendered to this apparently decaying industry is a question that many benevolent individuals will ask. Will not the British Government and people best remove present and future evils by assisting to develop the resources of their colonies, which, by the introduction of cotton cultivation upon a large scale, would be rendered productive and prosperous?

Shall no attempts, commensurate with the wants of this great industry, be made to obtain adequate supplies of cotton, and at the same time to benefit the dependencies and colonies of Great Britain? No charity can compensate for the losses now sustained, and effectual relief can only proceed from an abundant supply of good and cheap cotton.

A moral truth has now been taught the world—that slavery and tyranny shall not permanently yield prosperity; and the wrongs of the oppressed crying for justice, indicate that retribution is the corrective of iniquity. Experience and the physical construction of the earth both tell us that without adequate exertions there can be no beneficial result; and consequently, in this great country, when dangers are threatening extinction to any portion of the community, efforts must be called forth to sustain the social and industrial fabric. to contribute to the means of labor, to promote commerce, to extend civilization, and still to raise our national aims in the cause of humanity and of universal justice; that should prosperity again shine upon our country, there may be, in our distant intercourse and relations, no leading into captivity, and at home no complaining in our streets.

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*Association for the Prevention of Steam Boiler Explosions,  
Manchester.*

From the Journal of the Society of Arts, No. 520.

At the meeting of the Executive Committee, held on Tuesday, October 28th, 1862, the chief engineer presented his monthly report, of which the following is an abstract:—

During the past month there have been examined 353 engines and 539 boilers. Of the latter 9 have been examined specially, 9 internally, 48 thoroughly, 473 externally, in which the following defects have been found:—Fracture, 7 (1 dangerous); corrosion, 30 (3 dangerous); safety-valves out of order, 15; water gauges ditto, 7; pressure gauges ditto, 20; feed apparatus ditto, 7; blow-off cocks ditto, 27; furnaces out of shape ditto, 3; blistered plates, 5. Total, 121

(4 dangerous). Boilers without glass water gauges, 8; without pressure gauges, 7; without blow-off cocks, 18; without back pressure valves, 50.

Three explosions have occurred during the past month to boilers not under the inspection of the Association; these boilers were in the iron districts, and of the externally-fired haystack class; they were reported as having been of original defective construction, being insufficiently stayed. One of these explosions was attended with fatal consequences, the engineman being killed.

*Incrustation and Scum Pipes.*—The number of boilers under inspection which suffers from incrustation is very large; indeed, to escape this inconvenience is quite exceptional. It forms a considerable impediment to satisfactory inspection, since it renders it difficult to ascertain the actual condition of the plates; it sometimes gives a delusive appearance, and leads to undue suspicion of corrosion, but more frequently it conceals defects, since corrosion is often found to be going on under and to be caused by the deposit.

In addition to the waste of fuel occasioned by incrustation, the wear and tear of boilers is considerably increased, apart from the effects of over-heating. Thus internally double-flued boilers suffer from the undue longitudinal expansion given to the furnace crowns, which increase the tendency to groove at the front end plate, an action always more or less developed in these boilers, while incrustation renders the use of tubular boilers altogether impracticable in localities not supplied with good water, and thus prevents the more general use of this economical class of boiler.

Although the danger of allowing incrustation to form on plates exposed to the action of the fire is too fully appreciated to need remark, the fact is not so fully recognised that even where no actual cake of deposit is formed, over-heating frequently occurs. It is thought that this may, in many cases, be due to the presence of thickening matter held in suspension in the water, and it would be interesting to ascertain by experiment whether the impediment thus presented to the free escape of the steam does not—where the circulation is imperfect, or no such agitation of the boiler takes place as in locomotives when running—lift the water off the plates, and thus cause overheating. Of the fact of overheating occurring where no incrustation is formed, and with an ample supply of water in the boiler at the time, there is no doubt instances are constantly coming under notice, and it may be added that they are chiefly found to take place in boilers externally fired.

Apart from the injury done to the boilers from incrustation, a considerable amount of earthy matter passes over with the steam into the engines, and thus renders necessary the use of an increased amount of tallow for the piston and slides. This, though too frequently lost sight of, is illustrated by the fact that where boilers are fed from brooks, subject, on heavy rains, to sudden torrents which stir up the mud, the engine attendants are in the habit, at such times, of taking the pre-

caution of giving the engine cylinders an extra amount of lubrication, finding the pistons, &c., to clog when this is neglected.

Under ordinary circumstances, the most practical plan for the prevention of incrustation is the adoption of an efficient mode of "blowing-out," and not the use of "boiler compositions." To blow out, however, from one point only, at the bottom of the boiler, which is the general custom, has but a very limited and local effect. This is frequently remedied by the adoption of a perforated pipe, which is connected to the ordinary blow-out tap, and carried along the bottom of the boiler from one end to the other. These are technically termed "Topham-pipes," from the name of the patentee, and are generally spoken highly of by those of our members who have adopted them. They are, however, more successful where the sediment being heavy and sludgy falls to the bottom, than where it is of a lighter character, which frequently forms the hardest and most tenacious scale.

From the rapid ebullition that takes place within boilers when under steam, it is found that a greater part, if not the whole, of the sediment set free by evaporation, rises to the top of the water, forming a coat of scum, before finally depositing itself upon the furnace tubes or shell; and thus the readiest way of preventing incrustation is to blow out this layer of scum from the surface of the water by means of a scum pipe, before it has an opportunity of settling. There is nothing new or experimental in this; the system has been for years adopted with marine boilers, and there is no reason why its use should not become equally general with stationary ones. Many of our members have already tried it with considerable success, and find, on opening their boilers after a month or six weeks work, that where they used formerly to be coated with a heavy muddy deposit, they are now perfectly clean.

The following is an explanation of the description of pipe adopted: It is about three or four inches in diameter, having a wing cast to it on each side, so as to form a trough throughout the entire length of the pipe. This pipe is carried within the boiler, from one end to the other, being made in any convenient lengths for introduction at the manhole; it is perforated with small holes on the top all the way along, the aggregate area of the whole number of these holes being equal to that of the pipe itself. The top of the trough is fixed a few inches below the level of the water, so that the scum on the surface may flow over it, when, being guarded from the disturbance of the ebullition, it deposits in the still water above the trough the sedimentary particles held by it in mechanical combination. A tap is fixed to the front end plate of the boiler, in communication with this pipe, by means of which it can be blown out as frequently as is desired, which should not be less than once every two hours, when ebullition is going on. This tap, which need not be more than two inches in diameter, should be entirely of brass, fitted with a gland, and have a neat waste pipe attached, which may be of wrought iron, while also the waste pipes from the glass water gauges may be connected to it, being led immediately under the dead plate, which arrangement is found to be very compact

and convenient. The best position for the scum pipe is at the side, and not at the centre of the boiler, both on account of facility in fixing, and convenience of getting inside. A single pipe is sufficient.

The above description is not by any means given as if that were the only form of scum pipe that could be advantageously applied. It was designed for the use of the members as being adapted to stationary boilers, simple in construction, affording a large collection area, and being free from any patent right. Upwards of a year's trial has proved it to be successful, and its more general adoption is consequently recommended. These pipes have already been made by the manufacturing engineers of Rochdale, Bolton, Bury, and other places, but are needed more generally, and a drawing at the office is open to inspection for the benefit of the members.

There are other plans in operation which, however, are subject to patent right. One of these consists of a series of vertical pipes, fixed in the centre of the boiler, each pipe having a trumpet mouth, to which a vertical telescope movement is given, to allow for the changes of water-level, the movement being effected by a copper ball float, so that the trumpet mouth rises and falls on the changes of water-level, like a buoy on the rise and fall of the tide; the object being to keep the mouth of the pipe immediately below the surface of the water, in close proximity to the scum. A second plan consists of a trumpet mouth laid horizontally. Both of these arrangements are reported to give satisfaction, and, whenever opportunity offers, the results of their working will be noted, and particulars of the plan found to be most successful communicated to the members.

Some descriptions of incrustation, however, cannot be entirely removed by any blowing-out apparatus alone, however perfect; in such cases a little carbonate of soda may be added, which many of our members have applied with considerable success. Of the use of this, their experience is decidedly in favor, while the testimony with regard to complicated "boiler compositions" generally, is that they found them expensive, in many cases useless, in other injurious, and have, in the majority of instances, discontinued them altogether. For fuller chemical particulars refer to Dr. Angus Smith's report to the Executive Committee upon the Incrustation in Boilers. The use of soda, without a scum pipe, is found in some cases to induce priming; the soda combining with the grease within the boiler, and producing foaming of the water.

The general adoption of scum pipes is, therefore, confidently recommended to the members, not only for the prevention of incrustation, but also, in order to lengthen the lives of their boilers, as well as to assist the engines in many cases, by preventing priming.

The most radical cure for the prevention of incrustation, though one involving considerably more outlay at the first than the above, will be found in the adoption of dry or "surface condensation," by means of which the boiler is fed with distilled water, the same being used again and again, with the exception of the slight amount lost through leakage. To those who are paying large amounts annually for a supply

of town's water, and where the steam is consumed for engine purposes, the adoption of surface condensers is well worthy of serious consideration, not only on account of the saving in the water rates, but also in that of fuel, since non-condensing engines may, by this means, be converted into condensing, which is not at present generally the case where town's water is used.

*Results of an Experimental Inquiry into the Comparative Tensile Strength and other Properties of various kinds of Wrought Iron and Steel.* By Mr. DAVID KIRKALDY.

(Continued from page 317.)

From the Mechanics' Magazine, January, 1863.

In the discussion which followed—

Mr. Walter McFarlane said it was well known to all practical workers in steel and iron, that if they attempted to temper some kinds of steel articles in water they cracked; but that if they did the same thing in oil there was not the same danger of doing so. He did not know whether Mr. Kirkaldy had given, or could now give an explanation of the cause of the increased strength of steel when tempered in oil, as compared with that tempered in water? He would like to know whether the fibre altered, or what tended to produce the result.

Dr. Macquorn Rankine remarked that Mr. Kirkaldy disavowed in his book any attempt to explain the changes which took place in steel when plunged into water or into oil.

Mr. McFarlane said he thought there was an absolute necessity for their getting at the cause of that important result.

Mr. Kirkaldy in answer to the president, had nothing further to say upon the point.

Mr. D. More said that Mr. Kirkaldy invited "special attention to the practical use that may be made of the new mode of comparison introduced by him, viz: the *breaking strain per square inch of the fractured area of the specimen, instead of the breaking strain per square inch of the original area.*" That seemed to be the principal point hinged upon, as it was given in *italics*. Now he did not think it was even the breaking strain of the *fractured* area that must be considered, for after the iron was broken it drew out a little further. This sort of posterior action was shown in some experiments made by Dr. Rankine and himself in regard to iron and also brick. They found, in crushing the brick, that it withstood a considerable force, and afterwards crumbled away with a less force, thus showing that the breakage had really taken place before the brick had commenced to crumble away. In experimenting with an iron bar, it was observed that the iron drew out and became narrower at one part (as he showed by a sketch on the board) until the strength of the material was overcome. Then, immediately on the iron beginning to break, it drew out before it was finally completely separated, so that the fracture took place when the bar was a little bigger than it finally became. He thought

that the truth lay between the two areas—the original and the fractured area.

Mr. Kirkaldy said he had given the stretched area also in his tables, so that parties could judge for themselves. The three areas were given—the original, the stretched, and the fractured areas.

Mr. W. M. Neilson remarked that Mr. Kirkaldy's book was a mass of *data* from which to deduce results. He thought it was a very excellent thing that Mr. Kirkaldy had confined himself to giving facts, which would cause his book to be much more relied upon. He believed that Mr. Kirkaldy wished to lay his facts before the Institution for discussion, and that he would not be displeased, although they pulled them about as they liked. Regarding the effects of frost upon iron, upon which point he had never himself been quite clear, it appeared that frost did not affect the strength in a direct strain; but he had always had an idea, that perhaps not the drawing strain, but the breaking strain, was very much affected by frost. They all knew the fear they had of using chains in frosty weather. Now, he supposed that the strength of the chain links was very much diminished by the frost, and that the links broke not so much by direct tension as by a breaking strain.

Mr. Kirkaldy said his experiments on the influence of frost were all made with specimens taken from one bar. He regretted that the weather changed before he could carry out his intention of repeating those experiments with bars of various qualities. As the bar experimented upon happened to be of very good quality, perhaps they ought not to draw general conclusions from its behavior.

Mr. W. Simons said that in the operations attending upon the placing of a thousand-ton ship on a ship dock, during one frosty night, he had seen three rods  $3\frac{1}{2}$  ins. in diameter, broken, so that they had to stop and put fires to all the rods and joints, and after that none of the rods broke. In the International Exhibition, he had observed a very good specimen of Swedish iron, which some of the other members might also have seen, which was all crumpled like a hat, it being the bow of a steamer after collision. He did not believe that any Scotch iron would have stood such a test. He was of opinion that the result of Mr. Kirkaldy's investigations would be, that the present system of shipbuilding would be found to be entirely erroneous, and that for the future iron would be used in shipbuilding with its longitudinal fibre placed in the direction of the most constant strain, a principle which had hitherto been ignored in marine construction.

Mr. B. Connor said that some very interesting experiments, which had not been published, had been recently made by Messrs. Naylor and Vickers, at Sheffield, with a view of testing steel, so as to ascertain the best suited for railway axles and tyres. They had found that the material best suited for axles was the worst for standing great tension. They found that steel, which could bear only 35 tons of tension, was the best for journals. They tried steel with 15 cwt. falling from 1 ft. up to 36 ft. The tensional strength of the steel was then increased so as to stand up to 69 or 70 tons, but it broke with the

weight falling one-third of the space, and with less than one-half of the weight; and so that that which stood the greatest tension broke with the least concussion. He thought that between the highest and the lowest qualities of steel there was only a difference of one-fourth per cent. of carbon.

Mr. Kirkaldy thought that these experiments supplied strong reasons for taking the stretched and fractured areas into account.

Mr. B. Connor did not think the steel with the greatest amount of carbon, that broke almost short off, would show nearly so great a difference between the fractured and the original areas as the soft steel.

Dr. Macquorn Rankine concurred in what Mr. W. M. Neilson had said as to the very valuable collection of facts, most of them entirely new, which Mr. Kirkaldy had given in his book. It was a store-house from which they could all draw materials, and form their own conclusions upon them. Mr. Kirkaldy had very fairly described those facts, and it was the better that he had not set up any hypothesis upon them. One of the particular things which he (Dr. Rankine) remarked was, that the experiments of Mr. Kirkaldy seemed to point to the conclusion, that a process which many supposed to take place, namely, a change from the fibrous to the crystalline structure, had no real existence; and that the same piece of iron would show a crystalline or fibrous appearance accordingly as it was broken by a stroke or a strain. He came to the same conclusion himself nineteen years ago by experimenting on the fracture of railway axles, which when fitted up seemed to have been quite strong enough. He collected the broken-off journals of such axles; but he was sorry he could not now produce them, as no means had been taken to prevent the ends getting rusty. But he had made full sized drawings, colored from nature, of the more remarkable of them, which he presented to the Institution of Civil Engineers, along with a paper, an abstract of which was published, but the drawings were not published, and remained at that Institution, where they could be seen by any one. He still, however, possessed the originals of those drawings; and if it would be agreeable to this Institution to see them, he would produce them at a future meeting. Of course they were not so satisfactory as the original specimens, or as Mr. Kirkaldy's; but unfortunately the originals had been spoiled by rust. He got the journals of axles that had run two or three years, and had then broken off spontaneously, and almost every one of these showed a fibrous fracture, with here and there a crystalline spot. There was invariably a crack which had eaten in from the shoulder of the journal, and which was perfectly imperceptible until after the fracture took place. The crack seemed to have gone on until it had reduced the original diameter of the journal to one-half, and then the axle snapped; but it always presented a fibrous fracture, whilst if the same journals were broken off with the blow of a hammer, they presented crystalline or granular fractures. Accordingly, he had ever since thought it probable that a change from fibrous to crystalline, as supposed, was an erroneous hypothesis; and he believed that many other persons had come to the same opinion, and he was glad that Mr. Kirkaldy's ex-

periments corroborated it. An important point in those experiments was the calling attention to the comparison between the fractured area and the load that caused the piece to give way. Every one knew before, that bars of iron would draw out, especially if soft, before giving way; but never before Mr. Kirkaldy had any one accurately measured the final area to compare that with the load. He thought that there was a great deal in the principle Mr. Kirkaldy laid down as to testing the quality of iron by the comparison of the breaking strain with the fractured area; but he would not go as far as Mr. Kirkaldy and say that it was the most accurate test, although he had no doubt it was better than comparing the original area with the breaking load. The experiments of Mr. Kirkaldy had substantiated results that had been anticipated by theory. For example, it was a result of theory that the form of the longitudinal section influenced the breaking load per inch of area. Experimentalists, however, had not taken that into consideration before. Experiments were made upon the tenacity of bars that were for a long distance of a uniform diameter, but there had been experiments made with bars shaped so as to have an increasing diameter on both sides of the middle part (as he had pointed out on the board), and the result was a great apparent increase of strength. It had been perfectly well understood by writers on the theory of elasticity, that the shape referred to must give apparent increased strength to the narrow portion of the area, as the wider parts on each side resisted the tendency to draw out, which was not the case with the parallel bar. Experimentalists, however, had not taken this into account until Mr. Kirkaldy took it up and arrived at the results detailed in his book. Mr. Kirkaldy showed that the resistance of steel rivets to shearing was about a quarter less than the tenacity of the steel. That, also, was anticipated by theory. There was one very important point upon which Mr. Kirkaldy made some remarks, namely, as to the factor of safety—the ratio in which the breaking load ought to exceed the working load. Mr. Kirkaldy considered that the working load per square inch of the original area of the piece should be a certain percentage of the breaking load per square inch of the contracted area at the instant of being broken. He (Dr. Rankine) concurred in Mr. More's opinion, that the truth lay between the extreme views. He thought it would be going rather too far to make the working load per square inch a certain fraction of the breaking load per square inch of the fractured area. He might call attention to experiments made on the strength of steel by Prof. Tresca, of the French Government Corps of Engineers. They were made upon bars of steel cut out of boiler plates, and they showed the gradual elongation of the bar with the gradual increase of the load. The results were represented by a curve (of a kind sketched on the board by Dr. Rankine), the abscisses of which represented the loads, whilst the ordinates represented the elongations due to the loads. It was found that as the load was increased, the elongation increased at a uniform rate, until it reached a certain point, when there occurred a great increase in the rate of elongation, which was not quite sudden, though nearly so; and there resulted a



curve, the early part of which proceeded in a nearly uniform direction, and which merged by a quick bend into a portion proceeding in a different direction corresponding to the more rapid elongation. Now, he thought the point where the change in the curve of elongation occurred was that at which the strength of the material had been overcome. It was very probable that the drawing out, which was so conspicuous in Mr. Kirkaldy's experiments, began at that point, and that the greatly increased curve of elongation showed that the breaking had begun, and that the bar would break if the same load was simply put on it several times, without being increased, as was seen in Mr. Fairbairn's experiments. The experiments of this class were very interesting, taken in connexion with Mr. Kirkaldy's experiments. He thought, then, that the best test of the quality of the material was the strain at which the sudden change of the curve of elongation began; or, if that supposition of his was right, the point at which the drawing out of the fibres commenced. If they could only make experiments so precisely as to measure the area of the bar at the instant of change, and compare it with the load, and take the corresponding strain per square inch, they would get at the true strength of the material; it would give a result between that of the old method and that of Mr. Kirkaldy's method. But although it was very desirable to obtain such experiments, yet there were difficulties in the way of performing them upon the immense number of materials that Mr. Kirkaldy had experimented upon. The Institution could not be too grateful to him for his labors, for he had collected a mass of facts which were of the highest value in a scientific and practical point of view.

Mr. James Russell would like to notice one proposition in Mr. Kirkaldy's treatise as to the appearances presented by the bar fractured when the fracture was made suddenly or slowly. It appeared that iron broken very slowly had a fibrous appearance, whilst that snapped off was crystalline. They all knew that if they wished to judge of the quality of iron in a rough way, they would break it probably over the anvil and look at the fibre. They found that bars broken in the same way presented very different appearances. They also found that some of the bars broken by Mr. Kirkaldy were half fibrous and half crystalline. Now, if the appearance of the fracture was no sure test of the quality of the iron, then they were put in a very awkward position as to judging of any iron that came under their notice to apply to various purposes. He dared say that it would agree with all their experience that iron had been judged by the appearance of the break. It was also known that a chain working on a crane might have sustained great loads for a long time, and yet break with a very much lower strain, and the broken link have a very crystalline appearance. A case came under his own notice where the top chain of a Derrick crane bore a heavy strain, and yet broke with a third of the weight that had been on it previously, and the link presented a very crystalline appearance. He hoped other members of the Institution would make a few observations on this important matter.

The President asked what was the state of the weather when the rod broke?

Mr. James Russell dared say they had seen them break in all kinds of weather; but uniformly when the link of a chain broke with a comparatively light load, it was more crystalline in appearance than other links that stood the test. For instance, they might take one bar and give it a blow, bending it only, whilst another would with the like blow, snap at once like cast iron. They were in the habit of saying that the one that bended was fibrous, and the one that snapped was crystalline.

Mr. Faulds could not look on a crane chain being broken with a third of its previous load as a criterion by which they could judge of the strength of iron, for a careless man by giving it a jerk would bring it down. But with reference to breaking iron, so as to appear fibrous or crystalline, any smith could take a bit of the best iron and break it, either crystalline or fibrous, as he chose.

Mr. W. Macfarlane would call attention to another phase of the question besides the quality of the material. They must not lose sight of the fact that some firms turned out better work than others, although using the same materials, and that induced him to call their attention to the annealing of iron. The strength of iron was very much reduced by the breaking of the skin, so that the strength of a finished shaft was less than when it left the forger's hands. In articles of great value, when the safety of many lives rested upon the security thereof, it occurred to him that it would be well if wrought iron were annealed. He would like to know whether any extensive producers of such articles had made experiments on the annealing of iron work; and, further, what would be the expense if turned shafts were annealed or tempered in oil. His impression was that the same results must follow as with cast steel, and that the strength of the material would be very much increased by the annealing or by the tempering process of oil—these two modes of treatment being quite different in their results.

Mr. Faulds had thought that the breaking of the skin weakened a bar of iron; but he understood Mr. Kirkaldy to say that a turned bar would stand as much strain as an unturned one.

Mr. R. B. Bell wished to call to Mr. Macfarlane's attention the fact that Mr. Kirkaldy had drawn up these statistics from actual and accurately arranged experiments, so that what he had put forward were facts, not mere opinions or prejudices; and he would like to know if what Mr. Macfarlane stated was merely his opinion, or if he had made actual experiments with bars of equal sizes to ascertain this fact?

Mr. W. Macfarlane said it was from his own practical experience, but without making any special experiments to test the correctness of his deductions. His belief was that if the skin of an inch bar of cast iron were broken, it was weakened very much.

Mr. W. M. Neilson suggested that instead of "practical experience," perhaps Mr. Macfarlane should have said "practical prejudice."

Dr. Macquorn Rankine said he thought that no one would ques-

tion the greater strength of cast iron with the skin than without it; but as regarded wrought iron, he did not believe that there had been any precise experiments until Mr. Kirkaldy had made his. There was one matter about which there was no doubt; that if they had to turn a piece of wrought iron they ought to interrupt, as little as possible, the contiguity of the fibres; this was to be insured by forging it as nearly to the required shape as possible, so as to have little cross-cutting of the fibres. He had verified that doctrine at the time when he experimented with the axles, nineteen years ago.

The President said that the skin of all malleable iron was broken in bringing it into use, as in tyres, axles, &c.

Dr. Macquorn Rankine said that if they took two journals of the same diameter that had been turned alike, but which had been hammered down to different forms, although they were of the same dimensions, yet on account of the contiguity of the fibres in the one not being interrupted, it was stronger than the other in which the fibres were cut by the turning process.

Mr. Macfarlane said he hoped they would excuse him pressing upon them the importance of annealing important forgings. His own opinion was that it would materially strengthen them.

Mr. W. M. Neilson remarked that he thought what Mr. Macfarlane insisted on was, in other words, to make the iron more homogeneous.

Dr. Macquorn Rankine said there was one other fact of considerable importance that Mr. Kirkaldy brought out, which had been anticipated by theoretical writers, that the stretching of the metal tended to diminish its density.

Mr. R. B. Bell drew attention to the fact which Mr. Kirkaldy had made known, that galvanizing did not hurt the strength of iron in large sections; and he could add, that it did not do so in small ones, as had been proved in testing galvanized and ungalvanized wire ropes.

Mr. Macfarlane would like to know what process of galvanizing was referred to, as the one was a mechanical combination with the iron, while the other was chemical.

Mr. Kirkaldy said it was the chemical process.

Mr. W. Simons believed that, with reference to galvanized iron ropes, the result had been quite the opposite of that stated by Mr. Bell.

Dr. Macquorn Rankine said he had made experiments on that subject, and the result he came to was that the ungalvanized iron was, perhaps, a shade stronger, but the galvanized was more extensible. The result was, that what the galvanized rope wanted in tenacity, it more than made up by being more extensible, and it was, therefore, better able to resist a shock. The difference in tenacity, however, was so small, that it might have arisen from errors in the experiments. One peculiarity he had observed in galvanized wire was, that when a certain pull was put upon it, much of the elongation that took place was permanent. Perhaps that arose from the compression of the layer of zinc. The permanent elongation did not increase by repeated applications of the load, provided the load was within the limits of safety.

Mr. D. More asked if Mr. Macfarlane thought that if they annealed

forgings before they were finished it would add to their strength, or must they be annealed after being finished?

Mr. Macfarlane replied that they should be annealed when they came out of the forger's hands, but tempered after they were finished.

Mr. D. More asked—Would there not be some danger of the shaft getting warped?

Dr. Macquorn Rankine asked if Mr. Macfarlane intended them to be put into cold oil?

Mr. Macfarlane answered in the affirmative.

Mr. Faulds said that there would be a danger of twisting a shaft if it were annealed after being finished.

Mr. Macfarlane said that the strength would be increased, but admitted the danger of twisting.

The President then proposed the thanks of the Institution to Mr. Kirkaldy for bringing so valuable a series of experiments before them. He thought they would all agree with him, that the discussion should be adjourned, in order that members who were absent might have an opportunity of giving their views on that important subject, and also in order that they might have an opportunity of inspecting the drawings which Dr. Rankine had so handsomely offered to lay before them.

The vote of thanks was passed, and the discussion adjourned.

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### *Statistics of Coal in Great Britain.*

from Herapath's Railway Journal, No. 1227.

Mr. Hunt estimates that 83,635,214 tons of coal were raised in the United Kingdom last year. Of this amount Durham and Northumberland, with 217 collieries, contributed 19,144,965 tons; Cumberland, with 28 collieries, 1,255,644 tons; Yorkshire, with 397 collieries, 9,374,600 tons; Derbyshire and Nottinghamshire, with 180 collieries, 5,116,319 tons; Leicestershire, with 11 collieries, 740,000 tons; Warwickshire, 16 collieries, 647,000 tons; Staffordshire and Worcestershire, with 580 collieries, 7,253,750 tons; Lancashire, with 373 collieries, 12,195,500 tons; Cheshire, with 39 collieries, 801,570 tons; Shropshire, with 66 collieries, 829,750 tons; Gloucestershire, Somersetshire, and Devonshire, with 112 collieries, 6,514,025 tons; Wales, with 398 collieries, 8,561,021 tons; Scotland, with 424 collieries, 11,081,000 tons; and Ireland, with 46 collieries, 123,070 tons. The coal production of the empire appears to have largely increased during the last eight years. Thus, in 1854, with 2397 collieries worked, 64,661,401 tons of coal were raised; in 1855, with 2613 collieries, 64,453,079 tons; in 1856, with 2829 collieries, 66,645,450 tons; in 1857, with 2867 collieries, 65,394,707 tons; in 1858, with 2958 collieries, 65,008,649 tons; in 1859, with 2949 collieries, 71,979,765 tons; in 1860, with 3009 collieries, 84,042,698 tons; and last year, with 3052 collieries 83,635,214 tons. Of this vast quantity, only 7,560,758 tons of coal, 286,150 tons of coke, and 79,017 tons of patent fuel were exported, the remainder being absorbed at home. France was last year our best customer for coal, having taken 1,436,160 tons (this year the exports

in the same direction have been somewhat reduced in consequence of the use of French coal for the Imperial navy); Denmark came next, with 542,567 tons; Hamburg, 514,427 tons; Prussia, 439,096 tons; Italy, 417,629 tons; Spain and the Canary Islands, 403,238 tons; America (Atlantic Ports), 349,931 tons; Russia (northern ports), 342,513 tons; the foreign West Indies, 262,932 tons; Holland, 262,868 tons; Sweden, 214,004 tons; British India (continental territories), 199,060 tons; Turkey, 174,686 tons; the British North American colonies, 165,824 tons; Brazil, 157,281 tons; Norway, 135,221 tons; the British West Indies, 127,768 tons; Malta, 115,731 tons; Portugal, the Azores, and Madeira, 108,794 tons; and Hanover 100,312 tons. Our other foreign customers took less than 100,000 tons each.—*Times*.

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*Wood Preserving Processes.*

From the London Builder, No. 1050.

I have read with much interest the article in your journal entitled "Notes on the Properties of Wood." Noticing the importance you attach to the different processes for preserving wood, I make so bold as to offer you some data which have been arrived at in Belgium, Holland, and France, concerning their relative merits. It is quite true, as you say, that the continental engineers esteem the processes of English origin the most highly, and especially Mr. Bethell's creosoting process. The efficacy of the creosoting process has for some years been admitted in the most absolute manner by the engineers in the Netherlands, and no other wood preserving process is used by them. It has been proved in an equally absolute manner in Belgium by a series of experiments upon the principal wood preserving processes, made by the Belgian Government engineers. These experiments have lasted through a period of twelve years, and were conducted with the greatest care and vigilance. In the course of these experiments there were laid down creosoted sleepers, 223,654; sleepers prepared with sulphate of copper, 199,061; sleepers prepared by other processes, 25,730. And in 1860, *Compte Rendu des Opérations des Chemins de Fer Belges*, 1860," p. 28, the Minister of Public Works published his determination to prepare in future all railway sleepers with creosote, except the oak sleepers, which are not to be prepared at all. M. Crepin, a Belgian Government engineer, who has tried experiments upon the relative advantages of creosote and sulphate of copper for the preservation of timber in marine constructions from the attacks of worms, &c., has lately published a report, *Annales des Travaux Publics de Belgique*, tome 19, in which he states that creosoting is the only process he has found to succeed for this purpose. Indeed, he states that sulphate of copper affords no protection whatever against the action of salt water and marine insects.

As regards France, I must add that although immense quantities of timber prepared with sulphate of copper have been used by the French railways; nevertheless, there also, experience points to the

condemnation of this preservative. At the end of the last year, the committee of the Belgian engineers being unable to reconcile the facts they had observed in Belgium with the opinions of the French railway engineers, and fearing lest the failure of sulphate of copper in their experiments had been occasioned by some imperfection in their mode of employing it, the Belgian Minister of Public Works asked permission from the Nord and other railways of France for a committee of Belgian Government engineers to inspect the sleepers prepared with sulphate of copper and placed on the said railways in France. The result of the inspection made by the committee proved to them that no better results had been obtained in France than they had obtained in Belgium; and that consequently they had not to blame themselves for any want of skill in their application of the sulphate of copper process. It was quite by chance, through my being in London for a few days, that I came to read your article; and it is in the interest of truth alone that I send you the above facts, which I hope you will kindly place in your next number.

The Belgian Government now require that all the wood sleepers used in the state railways should be creosoted; and the Government of Holland have also made the same resolution; and upwards of 300,000 sleepers per annum are now being creosoted for the Dutch Government, and more by the Belgian Government. A. T., Antwerp.

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*On a New Chrome Green.* By M. MATHIEU PLESSY.

From the London Chemical News, No. 166.

The following is my method of operating:—

In 10 parts of boiling water I dissolve 1 part of bichromate of potash; to this I add 3 litres of biphosphate of lime, then 1.250 kilogrammes of brown sugar.

After a little time a tumultuous disengagement of gas takes place, which must be moderated by sprinkling over the froth.

After calcination the whole is left to stand, and by the following day the green is deposited. The supernatant liquid, of the color of salts of chromium, decant, and wash the precipitate with cold water until the acid re-action ceases; it is then placed on a cloth, *essoré*, and taken to the stove.

The above quantities give 2.500 of product.

This green containing, as we have shown, no poisonous substance, is unalterable in the sun; sulphuretted hydrogen has no effect on it; acids, even though concentrated, do not destroy it, or, at least, act very slowly as solvents. In fixing it by albumen, and printing with it, there is no inconvenience, except a slight paleness of tint.

By the firm of Betremieux it has been used in printing on a plain paper ground, producing an agreeable water green color. As a smooth ground it has also been employed as an oil color at the Louvre, and the tint has remained unaltered since its application a year ago.—*Repertoire de Chimie Pure et Appliquée.*

*Some Remarks upon Light.* By Mr. B. S. PROCTOR.

Read before the Newcastle Microscopical Society, at the December meeting.

From the London Chemical News, No. 164.

As the paper was somewhat lengthy, and the points suggestive of discussion numerous, it was agreed to have the paper printed and distributed among the members previous to its discussion at the January meeting. The following is an abstract of its contents:—

The speaker commenced by remarking upon the transparency and brightness which are revealed by a microscopical examination of objects commonly said to be dull opaque white, and the translucency of so-called opaque bodies, of whatever color, if reduced to thin films. Such common-place observations, he said, had suggested to his mind a variety of questions, the elaboration of which formed the material of his paper. The first point considered was, whether the transparency of white materials was universal, and, if so, what was the difference between the white powders, such as carbonate of lead, which are said to have strong "body,"\* and those which, like carbonate of magnesia, are wanting in this property. From the number of white powders which had been examined, all proving to have considerable transparency, it was inferred as a rule that, in white powders, pretty free transmission of light takes place through the individual particles.

The phenomena of body were explained and illustrated by the action of three bundles of glass plates, one being immersed in oil of turpentine, another in water, and the third being dry. The latter was shown to have most body in consequence of the great difference between the refractive power of the glass and the films of air intervening; but where a medium of refractive power approaching that of glass existed between the plates, much less reflection and more transmission took place; thus, magnesia, which appears to have considerable body while dry, loses it when mixed with oil, from their refracting powers being nearly equal. White lead retains its body when ground in oil, because of its refracting power being much higher than the oil. The difference in the body of precipitated coil-lead, and that made by the old process, was next explained by showing that where there was apparently equal comminution in the two, the particles of the precipitated carbonate consisted of clear crystals; while in the other variety the particles consisted of aggregations of smaller particles, each of which was transparent in itself, but in the aggregate was scarcely translucent.

The white surface of dead silver was next noticed, and the microscope showed that the light reflected from it consisted of mixed, not of combined colors.

The attention of the meeting was then drawn to the bearing some of these facts have upon the mounting of microscopic objects; for example, *Tous-les-mois* was shown mounted dry, mounted in gelatine, and in balsam; its markings were much more clearly seen when the mounting medium was of a refracting power a little less than the starch.

\*"Body" is the power of hiding that which is beneath them when laid on as pigments.

The translucency of white material having been acknowledged, the question, "Is anything opaque?" was next considered; and it was shown that no definite line could be drawn between transparent and opaque bodies; for, while nothing is found to transmit light without some loss, nothing is found absolutely impervious to light when reduced to a thin film. In most cases where much light is obstructed, some rays pass more freely than others, as indicated in the following table:—

LIGHT TRANSMITTED.					
Through gold-leaf,	.	.	.	.	is green.
" " tempered	.	.	.	.	" brown.
" gold chemical films,*	.	.	.	.	" grey violet.
" " " powders,*	.	.	.	.	" red, purple, or blue.
" silver-leaf,	.	.	.	.	" grey violet.
" " chemical films,	.	.	.	.	" purple or brown.
" copper,	.	.	.	.	" green.
" antimony,	.	.	.	.	" grey.
" arsenic,	.	.	.	.	" brown.
" platina,*	.	.	.	.	" grey.
" palladium,*	.	.	.	.	" grey.
" rhodium,*	.	.	.	.	" brown or blue.
" charcoal,	.	.	.	.	" grey.
" iodine,	.	.	.	.	" red brown.

Taking the word "opaque" in its ordinary acceptation, the question, "Are all opaque bodies black when in a fine state of division?" was next discussed; and it was shown by diagrams how the breaking up of a smooth surface diminished the amount of light availably reflected from it. It was also shown that comminution produces subjacent surfaces which reflect some of the light transmitted by the first surface, and that with a certain degree of fineness the more transparent the material the more light will be reflected from the subjacent surfaces; and it was concluded that bodies become lighter colored by powdering if their power of absorbing light is so small that the reflection from the subjacent surfaces more than compensates for the loss of reflection from the breaking up to the primary surface; and they become darker if the absorbing power is so great that the reflection from the subjacent surfaces does not compensate for the loss of reflection caused by the breaking up of the primary surface.

The doctrines of correlation and conservation were then briefly treated, and it was argued that light falling upon black bodies was neither annihilated nor absorbed, but converted into some invisible form or force; the power of the black body being, in some degree, the converse of that possessed by fluorescent and phosphorescent bodies, by which they convert invisible into luminous rays.

The fact, that reflection is not purely a superficial phenomenon, was then pointed out, as indicated by those parts of a soap-bubble which are too thin to reflect light being still possessed of two surfaces; and the questions were raised—If matter at some depth, however small, beneath the surface, continues to reflect light, at what depth

\*These are quoted from Faraday in *Phil. Mag.*; the others were exhibited to the meeting.



does it cease to do so? Does it ever cease to do so? Or does the transmitted ray, as it speeds on its journey, always send back a beam in the opposite direction?

Different kinds of reflecting surfaces have different appearances; this is probably due, in some measure, to the effect produced upon the light by its passage into and out of that thickness of matter which is concerned in ordinary reflection.

Of homogeneous matter, we have opaque and transparent; the former giving metallic lustre, the latter vitreous. As a general rule, if not a universal, we find the more nearly a substance approaches the metals in opacity, the more it resembles them in the nature of its lustre. Thus sulphurets are in many cases very nearly opaque, and very like metals in the nature of their lustre. Carbon in its opaque form is a brilliant steel grey; while its transparent form has the vitreous lustre.

A micaceous or pearly lustre is the result of the superposition of a number of films of transparent material; the reflection from the first surface being added to by the reflections from the subjacent surfaces.

When light falls upon glass and is reflected, it is commonly said that the glass reflected. The speaker drew attention to the important part played by the air or other medium in contact with the reflecting surface, and illustrated it by obtaining total reflection from the surface of a prism when air was in contact with it, and only feeble reflections when the air was replaced by water or oil of turpentine; even a film of silver deposited on the prism was shown to reflect less light than a film of air. By a simple contrivance it was then shown that white paper reflects more light than a looking-glass, and that the appearance of lustre depends upon the reflection of shadows as well as of lights.

Mr. Proctor concluded his subject with the following words:—

“Sir D. Brewster, and other writers on optics, give the length of a wave of white light, the number of undulations in an inch, and the number in a second, calculating it as the *mean* of the number of undulations in the colored rays; apparently forgetting that it is not the mean but the sum of the colors which forms white light—the mean being, according to Brewster’s own table, yellow, with a tinge of green. Various writers have, probably, copied from the same source without investing thought upon the subject; one indication of which is, that several say so many millions of millions, whereas it would be more natural to say so many billions. I will just give you Brewster’s figures, and then pass on:—

	Length in parts of an inch.	No. in an inch.	No. in a second. Millions of Mil- lions.
White, . . .	0.000225	44444	511
Yellow, . . .	0.000227	44000	535
Yellow Green .	0.000219	45600	553

“You observe the numbers given for white light are the same that would belong to a color between yellow and yellow-green. White light, we may conclude, is not a definite undulation, nor a definite mixture of undulations, but a variety of mixtures of undulations, in any of which mixtures the average length of an undulation is that given by Brewster and others, but the number in an inch or a second is incalculable and indefinite. The lengths of the undulations in a pure unmixed color is probably definite, and we have no reason to object to the measure and number usually adopted ; we shall, therefore, accept them for further argument.

“The length of an undulation of violet light is seventeen-millionths of an inch ; the red undulation twenty-six millionths, or about one-half longer ; undulations, longer or shorter than these, not being visible. The colors observed in soap bubbles and other thin films are produced by interference of the luminous waves. The color produced depends upon the relation between the thickness of the film and the length of a wave of light. A film of air, four millionths of an inch thick, produces the same color as a film of water three-millionths, or of glass two-and-a-half millionths of an inch thick. Therefore, we conclude that the length of the light wave varies with the medium. An undulation in air, measuring four, will measure only two-and-a-half when it enters glass, and will again elongate to its former measure on its exit. From these premises we may deduce various interesting conclusions. Faraday found that gold films were iridescent when they were only one-tenth the thickness at which air ceases to be iridescent. May we, then, conclude that light, while passing through gold, consists of undulations only one-tenth the length of those in air ? Newton found that the thickness of films of a given color was inversely proportionate to their indices of refraction. May we, then, conclude that gold has a refracting power in like proportion ? If we say that luminous undulations, which in air measure twenty-two millionths of an inch, look yellow when they enter the eye, and in that organ measure one-third less, in consequence of its refracting power, then we come to the singular conclusion that the blue sky is yellow, sunshine is red, and the rosy tints of evening are not luminous at all until they enter the eye. If the color depends upon the length of the light wave, and the length of the wave depends upon the refracting power of the medium through which it is passing, every beam of light changes color ; red it may be on its passing through the region of the stars, yellow or green it may be when it enters the air, blue or violet when it enters water, non-luminous as it passes through glass. But if light, which we perceive as violet while it exists in the aqueous humor of the eye, was red originally, what color must that light be which we perceive as red ? Its undulations in air must be too long to be luminous. This introduces us to the solemn thought, that all this vast universe is dark ! Light exists only in the eye. It is only a sensation—a perception of that which in nature exists as a force capable of producing a sensation. We would feel grieved at the thought of light and sound having no tangible existence independent of ourselves, were it not for the glori-

ous hope that all nature is full of forces equally grand—forces which we have not the power of perceiving, but which, with a higher development of our organism, may be sweet as music and genial as sunshine.”

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*Austrian Gun Cotton.*

From the London Chemical News, No. 175.

Take cotton-yarn and twist it into strands of suitable size to answer the same purpose as grains in gunpowder. (The size of these strands can only be ascertained by experiments.) It is then steeped for a few minutes in nitric acid contained in a stoneware vessel, squeezed, and thoroughly washed by water, which is permitted to fall upon it from a pipe set at a height of several feet. After this it is squeezed, and dried in a room heated to 130° Fahr., when it is ready to be treated with a mixture of nitric acid of 1.52 specific gravity, and sulphuric acid of 1.14 specific gravity. These acids, in equal quantities, are mixed together in a glass or stoneware vessel, and allowed to stand for twenty-four hours; then the prepared yarn is immersed in it for forty-eight hours, with occasional stirring; the vessels being covered; then it is squeezed, washed for several hours in running water, and dried again. After this it is soaked for a short period in dilute silicate of potash, squeezed, washed again, dried, and is fit for use. This gun cotton is manufactured by M. Reny, of Vienna. It emits but little smoke, and is not subject, like common gun cotton, to explode by percussion.

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*Discharge of Artesian Wells, observed at Different Heights.* By M. MICHAL.

From the Gas Light Journal, No. 269.

M. Darcy, Inspector-General of the Department of Roads and Bridges, has investigated the general laws which regulate artesian wells, in his interesting work upon the public fountains of Dijon. The formulæ at which this eminent engineer has arrived are established on two distinct hypotheses, comprising, first, the artesian springs due to meeting with a subterranean current; and, secondly, the springs fed by sandy water-bearing strata, in which the water moves with an insensible velocity. In the latter case, which is the most general, it is possible to deduce from the formula applicable to it, by neglecting some terms which may be considered of no value, the law, that the difference between the heights at which the water flows above the soil is sensibly proportional to the difference of the volumes observed at those heights. It follows from this, that if the result of two observations of the delivery of an artesian well are known, it is possible to form an equation of the first degree, which should yield, in an approximate manner, the produce of the same well at heights above the soil different from those at which the observations, which served to form the equation of the first degree, were made.

This law is confirmed by the experiments, made with the greatest

care at the well of Grenelle, about the end of February, 1844, by M. Mary, Inspector-General, and M. Lefort, Engineer-in-Chief of Roads and Bridges. But a formula of interpolation is thus obtained, in which the diameter of the ascensional tube, and its height, measured from the artesian spring to the point of overflow of the waters, are entirely omitted. It must, however, be understood that it is important to take into account the influence these elements may exercise upon the yield of a well, and to establish, consequently, a formula which should be a function of the height of the ascensional tube and its diameter. I propose at present to investigate these conditions.

When, in an artesian well, the movement has become uniform and permanent, there is an equilibrium between the effort resisting the motion of the water, and the unknown effort producing the motion, which acts upon the lower part of the tube to produce the ascensional movement in the water of the stratum which yields the artesian spring. An observation of the quantity discharged, under these circumstances, would indicate the motive power, as a function of the *work resisting*, corresponding with the quantity so discharged. It is possible, therefore, generally to obtain another discharge, by rendering the resisting work which results from it equal to the working power ascertained by the first method of observation. This will remain a constant quantity, provided the new combinations do not introduce any disturbing elements in the *régime* of the artesian stratum.

We should thus obtain the formula—

$$(A) \quad q_u = \frac{2 q_o H_o - g h_u \omega}{2 (H_o + H_u)}$$

in which the resistance resulting from the friction of the water in the ascensional tube, and that resulting from the loss of the *vis viva* at the lower end and at the upper end of the tube, are not taken into account. We should have, nevertheless,  $q_o$  equal to the discharge observed at the height,  $H_o$ , above the artesian stratum,  $g$ , the double of the space traversed during the first moment of its fall;  $\omega$ , the section of the lower part of the tube;  $q_u$ , the delivery calculated at a height,  $h_u$ , above the point of discharge of the volume,  $q_o$ . If we suppose the section of the tube to remain constant throughout its length, we should deduct from the formula (A)—

$$(B) \quad q_u = \frac{2 v_o o H_o - g h_u o}{2 (H_o + h_u)}$$

in which  $o$  represents the constant section of the tube, and  $v_o$  the rate of discharge per second of the discharge observed. The formula (B) shows that, by collecting in the same boring the waters resulting from different diameters, the product, all other things being equal, augments with the diameter of the bore; but that this condition may be fulfilled, it is necessary that the water-bearing stratum should furnish the water discharged at the orifice, without encountering any variations. But experience has proved that the power of artesian springs has limits which cannot be surpassed. It will be easy, then, to believe that, in a

boring which reaches a stratum yielding an artesian supply, there is a diameter to be adopted for the ascensional tube, which will yield the maximum of the delivery that can be obtained at a given height above the water-bearing stratum.

We will now proceed to apply our formula, and that of M. Darcy, to calculate the rate of discharge of the wells at Grenelle and Passy.

*Well at Grenelle.*—We will take, to determine the constants of the formula (A), the observation No. 1; and, to form the equation of the right line of Darcy, the observations Nos. 1 and 10 of the subjoined table, which reproduces the values of the discharges observed at different heights by MM. Mary and Lefort, and that calculated in the two hypotheses indicated:—

Number of Observations.	Height of the Points of Discharge observed above		Discharges		
	The Sea.	The Soil.	Observed by MM. Mary and Lefort.	Calculated by Formula.	
				(A.)	Darcy.
			m.	m.	m.
1	37.90	0.00	0.02000	0.02000	0.02000
2	40.95	3.05	0.01867	0.01925	0.01930
3	43.00	6.10	0.01822	0.01852	0.01861
4	50.00	12.10	0.01700	0.01711	0.01724
5	52.40	14.50	0.01638	0.01655	0.01669
6	53.55	15.65	0.01588	0.01628	0.01643
7	56.30	18.40	0.01524	0.01567	0.01580
8	62.95	22.05	0.01426	0.01425	0.01428
9	66.40	28.50	0.01342	0.01339	0.01349
10	71.00	33.10	0.01244	0.01236	0.01244

It will be seen that the discharges, calculated by either formula, differ but little from those observed; nevertheless, they are rather less exactly reproduced by the formula of Darcy than by our own, which is completely determined when a single discharge is known. So that it would have been possible to have calculated, by means of the formula (A), controlled by a single observation upon the surface of the ground, in a manner sufficiently near, all those observed above the first point recorded by MM. Mary and Lefort. It is necessary to observe that these results are obtained in the hypothesis that the artesian spring should communicate with the ascensional tube by the lower orifice; but it often happens that this communication takes place by means of an orifice greater or less than that of the above, whether it be increased by the formation of an excavation at the lower extremity of the ascensional tube, or diminished by the orifice being obstructed by fragments of rock, or by any other cause. In these cases it will be necessary to employ a second observation to determine the orifice of communication of the artesian spring with the ascensional tube.

*Well at Passy.*—The communication of the artesian spring with the ascensional tube takes place not only by the lower orifice, whose surface is equal to  $0^m\cdot3850$ , but also by the auxiliary apertures made in the lower part of the tube. By taking, for the sake of determining the contents of the formula (A), the observations Nos. 1 and 5 of the table hereinafter given—which contain those made in the end of 1861 and the beginning of 1862—we shall find  $\omega = 0^m\cdot5114$ . By forming equally the equation of the right line by the observations Nos. 1 and 5, we arrive at the following table, analogous to the preceding one:—

Number of Observations.	Height of the Points of Discharge observed above		Discharges		
			Observed.	Calculated.	
	The Sea.	The Soil.		(A.)	Darcy.
			m.	m.	m.
1	52·30	0·00	0·1779	0·1779	0·1779
2	59·32	6·02	0·1441	0·1504	0·1512
3	65·25	11·95	0·1197	0·1237	0·1248
4	73·15	19·85	0·0846	0·0889	0·0892
5	77·15	23·85	0·0718	0·0718	0·0718

It will be seen that in this case, also, the values deduced from the application of either formula differ very little from those derived from actual observation.

Extract by the Author, from the "Comptes Rendus de l'Acad. Sciences."

*On Aluminium Bronze as a Material for the Construction of Astronomical and other Philosophical Instruments.* By Lieut.-Colonel A. STRANGE, F.R.A.S.

The author, after referring to the astronomical and geodesical instruments about to be constructed, under his superintendence, by order of the government, for the use of the great Trigonometrical Survey of India, and after noticing that one of the points which has given him most anxiety had been the selection of the proper material or materials of which to construct these instruments, and that his present remarks were confined to the great Theodolite with a horizontal circle 3 feet in diameter, and after detailing the requirements of such an instrument, proceeds as follows:

Such then was the problem presented for solution: to construct an instrument with extended powers, and cast as much as possible in masses, the transportation of which over the most difficult ground should not be beyond the power of human labor.

When on the point of compromising the difficulty by separating, so as to form distinct packages, parts hitherto regarded as inseparable, my attention was attracted by the various articles made of *aluminium bronze*, sent to the International Exhibition by Messrs. Bell Brothers

of Newcastle, and M. Morin of Paris. The inquiries I made in various quarters satisfied me that this metal possessed most valuable qualities, but I failed in my endeavors to obtain reliable numerical data for comparing it with other metals. I therefore instituted experiments on it, the results of which I beg now to communicate to the Society.

The alloy called aluminium bronze was first, I believe, made by Dr. Percy five or six years ago, and is composed of aluminium and copper in various proportions, 10 per cent. of aluminium, however, giving the best material for mechanical purposes.

The qualities of most importance in instrument making are, 1. Tensile strength; 2. Resistance to compression; 3. Malleability; 4. Transverse strength or rigidity; 5. Expansive ratio; 6. Founding qualities; 7. Behavior under files, cutting tools, &c.; 8. Resistance to atmospheric influences; 9. Fitness to receive graduation; 10. Elasticity; 11. Fitness for being made into tubes; 12. Specific gravity.

Of these, tensile strength, resistance to compression, and malleability were most obligingly tested for me by Mr. Anderson at the Royal Gun Factory, Woolwich; and the other qualities by Messrs. Simms, by whom the great Theodolite is now being constructed. I will take the above enumerated properties in their order, premising that to have obtained results of an absolute and final character would have involved more time than I can spare, and that therefore those which follow, though sufficiently reliable for almost any practical purpose, are open to the correction of more extensive experiments..

1. *Tensile Strength*.—This was tried some years ago by Mr. Anderson with the following results:

Aluminium bronze,	.	95,747	} Breaking strain. lbs. per sq. inch.
Gun metal,	.	32,000	

Mr. Anderson was good enough to try it again for me in September last, and states in his report:—"The average tenacity of this metal proved to be 22 tons 12 cwt. (50,624 lbs.) breaking weight per square inch in the two specimens tested; elongations did not take place until 4300 lbs. in the one case and 3600 lbs. in the other had been applied, when a permanent elongation was noticed of .009 of an inch in the first specimen, and .034 of an inch in the last." Mr. Anderson adds that the specimens were not quite sound.

In the above cited report Mr. Anderson gives a higher tensile strength to gun metal than before, namely, 17 tons (38,080 lbs.) for the average of the "*best specimens*" tested at the gun factories.

Combining the results, we have the average breaking tensile strength of the two metals as follows :

Aluminium bronze,  $\frac{95747 + 50624}{2} = 73,185$  lbs. per sq. inch.

Gun metal,  $\frac{32000 + 38080}{2} = 35,040$  “ “

The ratio being 1 to 0.48, or rather more than 2 to 1 in favor of aluminium bronze.

For the purpose of comparing the tenacity of the new alloy with steel, we have data given by Mr. Anderson in a lecture on Materials for Rifled Cannon, in which he states that cast steel varies in tensile strength from 114,000 to 67,000 lbs. per square inch; but he objects to the higher qualities as liable to brittleness, and prefers, where great strains are in question, an average quality of cast steel breaking at 80,000 lbs.; and he adds, that specimens from a gun made of Krupp's famous cast steel, characterized by "softness" (which Mr. Anderson considers favorable to tenacity) and "perfect soundness," gave 72,000 lbs. per square inch, which we see is 1185 lbs. less than the average strength of aluminium bronze above given.

2. *Resistance to Compression.*—Mr. Anderson reports on this as follows:

"The ultimate amount of compression applied was 59 tons 2 cwt. 1 qr. 4 lbs. (132,416 lbs.), under which the specimen\* became too much distorted to permit of more weight being applied with any true result. Compression was not perceptible until 9 tons 2 cwt. per square inch (20,384 lbs.) was applied, when the specimen suddenly gave to the extent of .006 of an inch, and on the weight being removed an elasticity of .001 was observed, which gives the first permanent compression as .005 of an inch."

The compressive strength of cast iron varies a good deal. That of "Carron Iron, No. 3," the highest given in Ure's Dictionary of the Arts, is 115,542 lbs. per square inch; but it is difficult to compare in this respect two metals whose behavior under compression is so different, cast iron yielding suddenly and almost totally, and the new alloy more gradually and partially. Astronomical instruments, however, are more dependent on the rigidity or resistance to a transverse force than on any other quality.

3. *Malleability.*—Mr. Anderson states on this head:—

"The qualities of this metal for forging purposes would appear to be excellent; with the exception of the part heated to a red heat in the shade, all show that it is a good workable material under the hammer almost up to melting point."

I may add that there were specimens in the Exhibition, showing that the alloy could be drawn out under the hammer almost to a needle point.

I come now to the experiments tried by Messrs. Simms.

4. *Transverse Strength.*—As the absolute determination of the force necessary to break or permanently bend a bar of metal was beyond our appliances, I begged Messrs. Simms to be satisfied with a comparative value of the rigidity of the new alloy; that is, to ascertain the relative resistances of gun metal, brass, and aluminium bronze, to a force insufficient to produce permanent flexure. This they succeeded in doing, and report as follows:—

The same weight applied to three bars altered the index of our instrument thus:

\* "The specimen subjected to this enormous pressure, distorted though it is, does not exhibit the trace of a fissure. The cohesion of its particles is inviolate."



Brass,	.	.	.	.	2.22 divisions.
Gun metal,	.	.	.	.	0.15 “
Aluminium bronze,	.	.	.	.	0.05 “

Hence, aluminium bronze would appear to be 3 times more rigid than gun metal, and upwards of 44 times more rigid than brass.

5. *Expansive Ratio*.—This determination was also a comparative one. Messrs. Simms found that “aluminium bronze is less affected by change of temperature than either gun metal or brass (a little less than gun metal, and much less than brass).”

6. *Founding Qualities*.—Regarding this there is ample experience. The alloy produces admirable castings of any size.

7. *Behavior under Files, Cutting Tools, &c.*—In this respect, also, it leaves nothing to be desired. It does not clog the file; and in the lathe and planing machine the tool removes long elastic shavings, leaving a fine, bright, smooth surface. Messrs. Simms state: “It can be worked with much less difficulty than steel, and we should think that screws made of it would (notwithstanding the original great cost of the metal) prove in the end less expensive than screws made of steel.”

8. *Resistance to Atmospheric Influences*.—Messrs. Simms state, “it does not really tarnish.” This, likewise, is entirely a relative question. Absolute inoxidizability, however desirable, is hardly to be expected. Suffice it, that the new alloy tarnishes much less readily than any metal usually employed for astronomical instruments, viz: gun metal, brass, silver, cast iron, or steel.

9. *Fitness to receive Graduation*.—Messrs. Simms state, “Aluminium bronze takes a fine division, and it will not be necessary to inlay another metal, as is usually done, to receive the graduation.” This opinion is fully justified by the specimen of graduation executed by Messrs. Simms, the lines of which are remarkably pure and equable, characteristics never presented in the same degree, they inform me, by lines cut on any other *cast* metal. May not this superiority indicate that the alloy in question is peculiarly homogeneous? The lines are very distinct under the microscope, notwithstanding the yellow color of the metal.

10. *Elasticity*.—I possess no direct experiments bearing on this point. But that the alloy has considerable elasticity is unquestionable. I may here state that an eminent Parisian instrument-maker informed me, that of all the wires tried for the suspension of Foucault's Pendulum for illustrating the rotation of the earth, none, not even those of steel, were so durable under that severe ordeal as wires made of aluminium bronze. It would appear, therefore, to be the most proper material for the suspension springs of clock pendulums.

11. *Fitness for being made into Tubes*.—It admits of every process necessary for this purpose. It can be soldered with either silver or brass solder; it can be rolled into sheet metal; and it can be hammered and drawn. Hitherto telescope tubes, the cones of transit axes, the

pillars of altazimuths, &c., have been made almost exclusively of yellow brass, a metal very deficient in rigidity. Gun metal does not admit of being rolled, and has therefore never been used for the tubular parts of instruments, for which the new alloy seems pre-eminently suitable.

12. *Specific Gravity.*—The specific gravities of alloys of aluminium and copper, as determined by Messrs. Bell, are

3 per cent. of aluminium,	.	.	8.691
4   "           "       .	.	.	8.621
5   "           "       .	.	.	8.369
10   "           "       .	.	.	7.689

The last named, which is the best for the purposes now under notice, is very nearly the same as that of wrought iron, and less than that of either brass or gun metal.

It appears from these experiments, and from the concurrent testimony of those who have given it a fair trial, that the 10 per cent. aluminium bronze is far superior, not in one or some, but in every respect, to any metal hitherto used for the construction of philosophical apparatus, and that for such purposes it may be employed in the dimensions that would be proper in the case of cast steel. All parts which otherwise would be made of steel may, with perfect safety and even with advantage, be made of the new alloy, particularly such parts as bolts, and fixing tangent and micrometer screws. Its hardness and comparative inoxidizability point it out as peculiarly adapted for pivots, axes, and bearings. If employed for receiving the graduation of circles, the necessity for inlaying another metal will be obviated, by which two advantages will be gained; the hammering which forms part of the operation of inlaying, and which, more or less, must cause unequal density and tension in the circle subjected to such treatment, will be dispensed with; and the effect of inequality of expansion in the circle and the inlaid strip will no longer be a cause of apprehension. With respect to the due visibility of divisions cut on this metal, opinions will perhaps differ. I can only say that I should be well content to observe with them.

The use of this alloy for the construction of the new great Theodolite is, in the opinion of Messrs. Simms, and in my own, fully justified by what we now know of it; and the effect of using it will be to keep the weight of the instrument within reasonable limits, notwithstanding its possession of means and appliances not hitherto bestowed on such instruments.

Two points remain; the making of the alloy, and its cost.

The metal aluminium is at present extracted in England by one firm only, Messrs. Bell Brothers, Newcastle, under a license from M. Deville, the French discoverer of the process. I have met with instances of failure in making the alloy with copper. Two main points only, however, seem to require particular attention. First, extremely pure copper must be used. The best is copper deposited by electricity, but that kind is very expensive; the next best is copper from Lake

Superior, which makes an alloy of excellent quality. The ordinary coppers of commerce generally fail, owing, it is said, chiefly to the presence of iron, which appears to be specially prejudicial. The second precaution is to re-melt the alloy two or three times. The first melting of 10 aluminium and 90 copper produces an alloy of excessive brittleness. Each successive melting, up to a certain point determined by the working and particularly by the forging properties of the metal, improves its tenacity and strength. It is probable that after several meltings there will remain in combination with the copper a somewhat smaller proportion of aluminium than 10 per cent.

The present price of the English made 10 per cent. aluminium bronze is 6s. 6d. per lb., but there is reason to believe that, as the process of extracting the aluminium becomes more largely practised, and the demand for the metal increases, the price will fall. The above price is four or five times that of gun metal. A much smaller quantity, however, of the new alloy than of gun metal will give the same strength; and when it is considered how small a ratio the cost of the material bears to the cost of workmanship in refined apparatus, it will be found that even at the present price of the new alloy its cost is not prohibitory, whilst the advantages attending its use promise to outweigh the increased expenditure.

In the foregoing paper, which I am aware is very imperfect and incomplete, I have sought no more than to contribute such an instalment of practical information regarding this remarkable material as may be of service to those who, like myself, contemplate making use of it, of whom I trust there will be many, for by its use we shall, I venture to think, confer on such structures at once greater strength and less weight, and so diminish tension, flexure, and distortion, to an extent calculated sensibly to improve the higher order of instruments of physical research.

Proceedings of the Royal Astronomical Society, Nov. 14, 1862.

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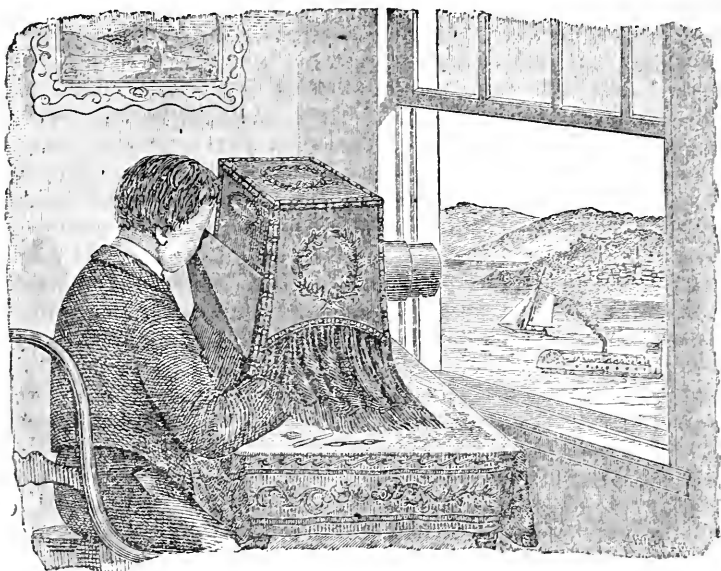
For the Journal of the Franklin Institute.

*G. F. Kolb's Improved Camera Obscura.*

The annexed cut represents a neat and compact camera for the use of artists and those who are interested in drawing either as a profession or as an amusement. The instrument consists of a case blackened on the inside, the most convenient form being that represented in the cut.

To the front side of the case is secured a tube in which slides another tube containing a lens, and in the opposite side of the case is an oblong opening surrounded by a similarly shaped tube; the latter being placed at such an angle that on looking through it the entire or nearly the entire bottom of the box is exposed to view. Opposite to the lens tube, in the interior of the box, is a reflector placed at such an angle as to cause the rays of light which pass through the lens to be thrown on to a second reflector which directs them on to a sheet of paper deposited upon the bottom of the case. On the right hand side

of the latter is an opening covered by a curtain, so that the hand may be introduced into the box and trace with a pencil the forms of the objects thrown upon the paper.



These instruments are well calculated to foster a taste for drawing and are useful in attaining the principle of perspective.

They are made in a great variety of style by Mr. G. F. Kolb, of this city.

### *Steel for Fire-Arms.*

From the London Artizan, May, 1863.

Capt. Caron has been for some time addressing papers to the Academy of Sciences about his experiments on steel, effected at the *Dépôt des Poudres et Salpêtres*, for the purpose of applying that metal to ordnance and fire-arms in general. More than twelve months ago, samples of a peculiar soft steel were brought to the artillery factories, and the remarkable qualities of this metal induced Colonel Trielle de Beaulieu, the director, to apply it to the manufacture of tubes intended to protect the copper of the points of sight of heavy ordnance. This steel has the property of drawing cold, in tubes of any dimensions, and after drawing—above all, if the metal be tempered—the grain, perfectly homogeneous, is fine and watered, the steel has become strengthened (*nerveux*), and offers an extraordinary amount of resistance. Since then, gun barrels, manufactured from the same material, have been presented to the factory for the models of arms, and Captain Maldin, director of this establishment, struck by the beauty of this metal, thought it his duty to try the barrels, in order to establish their quality. The following are the very curious results at which this

officer has arrived:—A gun barrel of the ordinary dimensions of that of a sporting gun, after having been trued, was tried first with 30 grammes (1 oz.) of powder, and one ball of 37 grammes (1½ oz.) This charge, producing no deterioration, was followed by trials with a ball of the same size, and increasing the charge by 10 grammes at a time up to 60 grammes (2 oz.) The 60 grammes were then replaced by 40 grammes of extra fine Esquerdes powder (the most destructive powder known). Not being able to burst the barrel, the experiments were continued with gunpowder, and after some trials, a charge of 150 grammes (5 oz.) was arrived at without inducing a rupture. A last experiment was then tried, in which 150 grammes (5 oz.) of powder and five balls were employed, the latter weighing together 135 grammes (say 4½ oz.) well rammed home. The only injury seen was a swelling in the barrel at the spot where each of the balls was placed, but the barrel was not burst, not even cracked. If it be considered that the charge of powder was already 23 ins. long, and that a more considerable quantity would not have had time to burn entirely, it may be fearlessly concluded from these experiments that the metal employed in the manufacture of these barrels is capable of giving arms which cannot be burst by the effort of any charge of powder whatever.

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*Strength of the Fibres of Orleans Cotton.*

From the London Practical Mechanic's Journal, May, 1863.

Mr. Charles O'Neill exhibited a mounted fibre of Orleans cotton, torn by a gradually increasing weight suspended to its extremity. It had sustained a weight (gradually increased) of 162 grains for many minutes. Mr. O'Neill stated that there were 143 such fibres in .01 grain of cotton, each fibre therefore weighing less than the ten-thousandth part of a grain. The strongest fibres were capable of supporting more than two million times their own weight. He is engaged in making experiments upon the tensile strengths of various fibres by a special apparatus, but they are not yet completed.

Proc. Manchester Lit. and Phil. Soc., March 16, 1863.

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*Dimensions of the Earth's Coal Fields.*

From the London Artizan, May, 1863.

Professor Rogers states, we have it on the authority of competent surveyors, that the great coal-field of South Wales, the largest and deepest in Europe, covers a surface of not less than 1000 square miles, and has a maximum thickness of from 7000 to 12,000 feet in its coal measures. In this prodigious "book of time," there are, it has been commuted, not less than 50 beds of coal, from 6 inches to 6 feet in diameter, and 25 of these are said to be each at least 2 feet thick. The smaller Forest of Dean coal basin contains, according to the "Memoirs of the Geological Survey," 31 coal beds in a thickness of coal measures of 2400 feet. From the same source (the survey) we learn that the North Staffordshire coal measures have an aggregate depth of about 5000 feet; while those of the Newcastle district are

believed to be at least 2000 feet thick, and to embrace a total thickness of coal equivalent to 60 feet. In the deepest portions of the extensive coal basin of Scotland, the upper productive coal measures of Mid-Lothian have been found by the survey to possess a thickness of not less than 1800 feet. The number of the seams of coal wrought in the Lanarkshire field is in all 18. Turning to other countries, the depths or thicknesses of the coal measures, and the numbers of coal beds, will be found to be on an equally grand scale. Looking first to the western side of the Atlantic, North America displays, commensurately with the breadth of her physical features generally, several enormous coal regions, three at least of which are the largest known upon the globe. One of these, the Appalachian basin, has a length of 875 and a maximum breadth of 180 miles, with an area in square miles of 55,500. Where deepest its coal beds have an aggregate thickness of 40 feet. A second, the coal-field of Illinois, Indiana, and Kentucky, has length, 370, maximum breadth 200, and area 51,100 miles. This basin has 15 or 16 good coal seams, with a maximum thickness of 50 feet, and the third and largest, but least opened, shows length 550, breadth 200, and superficial area 73,913 miles. In the anthracite basin of Pennsylvania, the thickness of coal measure, amounts to 3000 feet, while that of the workable coal is not less than 120 feet. The aggregate area of the five chief coal fields of the American continent, amount by careful estimates based upon the latest surveys and the best geological maps, to rather more than 200,000 square miles; a surface greater by about 20 times than the sum of all the coal-fields of Europe, or, indeed, of the whole Eastern world. The British carboniferous basins may be estimated to embrace some 5400 square miles of coal; the French a little less than 1000; and the Belgian about 510. Rhenish Prussia has 960; Westphalia 380; the Bohemian field some 400; that of Saxony only 30; that of Spain probably 200; and that of all Russia scarcely 100 square miles. Comparing the coal areas with the total surfaces of the respective coal producing countries, the United States has one square mile of coal to each 15 of land; Great Britain one to every  $22\frac{1}{2}$ ; Belgium a like proportion; and France but one of coal to every 200 of country. Adopting for the commuted total area of the coal-fields of the world 220,000 square miles, and accepting 20 feet (a low estimate) for the average thickness of the available coal, the entire mass of the fuel under the soil for the future wants of man amounts by calculation to a cubic lump of nearly ten miles lineal dimensions, or to a square plateau of coals of 100 miles wide in its base, and something more than 500 ft. in height. The British lump of coal is a cube of a little more than three miles in diameter. In 1854 Great Britain extracted from her mines more than 64,000,000 tons. In 1861 the product was about 80,000,000 tons, equal to a cubic block of 430 yards in height. For the present year the probable product may be safely estimated at not less than the enormous quantity of 100,000,000 of tons. In the preliminary report lately printed on the census of the United States for 1860, it is shown that the coal product of the state of Pennsylvania amounted in that year to about 11,500,000 tons, while that of all the coal yielding

states together exceeded 15,000,000 tons. In the year 1850 Belgium took from her mines nearly 6,000,000 tons; France some 4,500,000 tons, and Prussia nearly 4,000,000 tons. It has been calculated that one-fifth at least of the present vast product in coal of the civilized world, which fifth part we may roughly estimate at nearly 30,000,000 tons annually, is applied in the smelting and manufacture of iron alone, and it is probable that more than one-tenth of the whole of the fuel lifted, or some 15,000,000 tons, is converted directly into mechanical power, through the generation of steam for the propulsion of machinery.

For the Journal of the Franklin Institute.

*Evans, Jenkins, and Durborow's Governors for Steam Engines.*

Through mistake, this invention was described in the last number of the *Journal* as belonging to Messrs. Jenkins and Jumelle, the owners of the invention in Europe. The right to the invention in this country is vested in H. W. Evans, C. C. Jenkins, and W. H. Durborow, and should have been so stated.

H.

## FRANKLIN INSTITUTE.

*Proceedings of the Stated Monthly Meeting, May 21, 1863.*

John C. Cresson, President, in the Chair.

John Agnew, Vice President,

John F. Frazer, Treasurer,

Isaac B. Garrigues, Recording Secretary,

} Present.

The minutes of the last meeting were read and approved.

Letters were read from Thomas Oldham, Esq., Superintendent of the Geological Survey of India, and the Geological Museum, Calcutta, India, and from the Smithsonian Institution, Washington, City, D. C.

Donations to the Library were received from the Royal Society, the Royal Institution, the Royal Geographical Society, the Royal Astronomical Society, the Society of Arts, the Chemical Society, and the Commissioners of Patents, London; the Royal Irish Academy, Dublin, Ireland; the Geological Survey of India and the Geological Museum, Calcutta, India; the Société d'Encouragement pour l'Industrie Nationale, and l'Ecole des Mines, Paris, France; the Numismatic Society, and Major L. A. Huguet Latour, Montreal, Canada; Samuel McElroy, Esq., Brooklyn, New York; T. C. Zulich, Esq., Harrisburgh, Penna.; Isaac S. Cassin, Esq., the Select Council of the City of Philadelphia, and Professors John C. Cresson and T. S. E. Lowe, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of April.

The Board of Managers and Standing Committees reported their minutes.

The Standing Committee on Meetings reported that they have organized for the present year by electing Henry Howson, Esq., Chair-

man, and appointing the third Thursday evening in each month for their stated meetings.

A candidate for membership in the Institute (1) was proposed, and the candidates (3) proposed at the last meeting were duly elected.

Mr. Joseph Clay exhibited his Patent Air Spring Trusses. The pads consist of india rubber hollow semi-spheres, distended with air and covered with cotton fabric; they are mounted upon a piece of leather, having the usual straps and buckles. The ball has sufficient elasticity to perform its office, and at the same time yield to an unusual pressure if brought upon it by accident; thus preventing bruising of the part in contact.

The Committee on Meetings presented the following articles:—A piece of the Armor Plate of the Whitney Battery, *Keokuk*, punched through by a ball during the late attack upon Fort Sumter. It seems to have been struck by a nine-inch round shot, a portion of which was shown at the same time. The iron is of good quality, showing fibres at line of rupture. The blow was not perpendicular, judging from the appearance of the piece, which resembles the bowl of a table spoon, with the pointed part rounded off. The back or converse part where first struck, shows the stretching of the iron before rupture took place. The piece is evidently a part of the inner plate of turret, which is composed thus: first an inner plate of  $\frac{1}{2}$ -inch thickness, upon which are placed edgewise, bars of iron 1 inch thick by 4 inches wide, and  $1\frac{1}{4}$  inches apart; the interstices being filled with yellow pine wood; upon these are placed three plates, each  $\frac{5}{8}$ ths thick. The whole is fastened with bolts of  $1\frac{1}{8}$  diameter, passing between the bars, and riveted into countersunk holes. This battery was not intended to resist the action of heavy ordnance at short ranges, but was designed for shoal river service, where the guns are generally of comparatively small calibre. Hence, the armor was placed as described, in order to obtain the greatest strength with least weight of material, so as not to exceed a draft of 8 feet when fully equipped. There is no doubt she was a very suitable vessel for such service, but entirely unfitted for the part she sustained against Fort Sumter, being nearer to its guns than any of the Monitor vessels, whose turrets have about twice the amount of material in them.

Some specimens of Marine Parasites taken from the bottom of the monitor *Passaic*. They are from 2 to 3 inches in length, tubular and semi-transparent. The attachment of these weeds to iron vessels, cannot be prevented by any known means, the patent composition paints being useless.

Mr. J. C. Garrigues exhibited his Patented Portable Book-case, which is made in sections easily taken apart. The upright ends are hinged in the centre, so that when folded, their length is equal to the breadth of the case; the shelves are connected to the upright ends by dovetails; to each shelf is attached the portion of the back of the case filling the space between the shelves. The case can be readily taken to pieces when necessary to remove it, as two screws only are used in each end



of the top of the case to secure it to the upright ends, which are held in position by the dove-tailed shelves. An additional advantage is, that when taken to pieces, by reversing two shelves, with their portions of the back, over each other, boxes can be formed for packing the books and for holding the ends and top piece of the case.

The Committee on Meetings exhibited a number of Glass Jars of several kinds, sealed by an improved elastic cap, the patent for which was recently issued to Messrs. Hartell & Letchworth, of this city. This improved cap consists of a rigid plate or disc, of metal or other material, with an annular flanch of gum elastic, secured to the edge of the disc. By applying this cap to the mouth of any suitable sized vessel, and turning down the rubber flanch, the latter grasps the vessel with a contractile force sufficient to hermetically seal the same, and preserve any substance within it from the action of the external air.

Another self-sealing device of Mr. Hartell's was shown, as applied to jars containing peaches, pears, &c., which had been enclosed therein for over three years. The fruit was stated to have been placed in the jar as picked from the tree, without any other preparation than to cover it with cold water. To all appearances the articles thus preserved were as solid as when first picked.

A sketch illustrating an invention of Messrs. Stileman & Ellis, for Smelting and Melting Iron, was shown. This consists in applying to a foundry cupola, or other furnace, a box, between the upper and rear side of which and the base of the cupola, is a pipe, which conducts the metal as soon as melted, from the cupola to the box, the blast from the cupola passing into the box and out of an opening at the side. The object of the invention is to get rid of the slag and scoria which float on the top of the metal in the box, and are blown out of the opening at the side of the same by the blast, the pure metal being drawn from the tap opening at the bottom of the box. It was stated that by this invention, from old retorts, otherwise worthless, over 75 per cent. of iron might be obtained.

It was promised on the part of the inventors that a full description of the operation of the furnace and the results obtained under different circumstances, should be laid before the Institute at their next monthly meeting.

Mr. U. B. Vidal, of this city, exhibited several Coal Oil Lamps of his invention, the wick tube of which, above the base of the burner, assumes a fan-shape, so that as the wick is raised the upper edge of the same is spread out to nearly double its former width. By this simple invention the oil carried up by the wick is distributed over so extended a surface that it is entirely consumed, and no portion can remain to clog the wick or run down the outside of the tube, to be evaporated and discharged into the air of the room, as is the case where a large supply of oil is constantly brought to a small burning surface. No chimney is needed with this lamp, which burns without smoke and with a clear flame.

*A Comparison of some of the Meteorological Phenomena of APRIL, 1863, with those of APRIL, 1862, and of the same month for TWELVE years, at Philadelphia, Pa.*  
 Barometer 60 feet above mean tide in the Delaware River. Latitude  $39^{\circ} 57\frac{1}{2}'$  N.; Longitude  $75^{\circ} 10\frac{1}{2}'$  W. from Greenwich. By JAMES A. KIRKPATRICK, A.M.

	April, 1863.	April, 1862.	April, 12 Years.
Thermometer—Highest—degree,	71-00°	82-00°	88-00°
“ “ date, . . .	12th.	18th.	24th, 1861.
“ Warmest day—Mean,	60-17	70-00	74-30
“ “ date, . . .	12th.	18th.	29th, 1856.
“ Lowest, degree, . . .	30-00	28-00	20-00
“ “ date, . . .	4th.	9th.	7th, 1857.
“ Coldest day—Mean,	33-33	33-20	27-70
“ “ date, . . .	4th.	9th.	2d, 1857.
“ Mean daily oscillation,	14-90	17-87	16-73
“ “ “ range,	5-41	5-89	6-32
“ Means at 7 A. M., . .	43-95	44-57	45-49
“ “ 2 P. M., . . .	54-35	55-23	57-25
“ “ 9 P. M., . . .	47-40	48-23	49-27
“ “ for the Month,	48-57	49-36	50-67
Barometer—Highest—Inches, . .	30-185 in.	30-321 in.	30-518 in.
“ “ date, . . .	21st.	16th.	3d, 1854.
“ Greatest mean daily press.,	30-177	30-300	30-458
“ “ date, . . .	21st.	15th.	3d, 1854.
“ Lowest—Inches, . . .	29-260	29-422	28-884
“ “ date, . . .	2d.	22d.	21st, 1852.
“ Least mean daily pressure,	29-387	29-439	28-959
“ “ date, . . .	2d.	22d.	21st, 1852.
“ Mean daily range, . . .	0-164	0-146	0-172
“ Means at 7 A. M., . .	29-788	30-025	29-821
“ “ 2 P. M., . . .	29-752	29-979	29-779
“ “ 9 P. M., . . .	29-808	29-994	29-808
“ “ for the Month,	29-782	29-999	29-803
Force of Vapor—Greatest—Inches,	0-404 in.	0-555 in.	0-611 in.
“ “ “ date, . . .	30th.	18th.	22d, 1853.
“ “ Least—Inches, . . .	0-072	0-091	0-066
“ “ “ date, . . .	9th.	7th.	13th, 1852.
“ “ Means at 7 A. M., . .	0-207	0-211	0-231
“ “ “ 2 P. M., . . .	0-213	0-219	0-244
“ “ “ 9 P. M., . . .	0-232	0-228	0-249
“ “ “ for the month,	0-217	0-219	0-241
Relative Humidity—Greatest per cent.,	96 per ct.	94 per ct.	100 per ct.
“ “ “ date, . . .	16th & 24th.	9th.	Often.
“ “ Least per cent, . . .	15-0	18-0	13-0
“ “ “ date, . . .	26th.	27th.	13th, 1852.
“ “ Means at 7 A. M., . .	68-8	67-8	71-5
“ “ “ 2 P. M., . . .	50-4	48-5	51-2
“ “ “ 9 P. M., . . .	68-2	64-5	67-6
“ “ “ for the month,	62-5	60-3	63-4
Clouds—Number of Clear days,* . .	8	9	8-8
“ “ Cloudy days, . . .	22	21	21-2
“ Means of sky cov'd at 7 A. M.,	57-0 per ct.	68-7 per ct.	62-8 per ct.
“ “ “ 2 P. M., . . .	75-3	67-3	66-0
“ “ “ 9 P. M., . . .	58-0	49-0	52-4
“ “ “ for the month,	63-4	61-6	60-3
Rain—Amount, . . .	7-294 in.	3-947 in.	5-007 in.
No. of days on which Rain fell, . .	16	11	13-1
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\* Less than one-third covered at the hours of observation.

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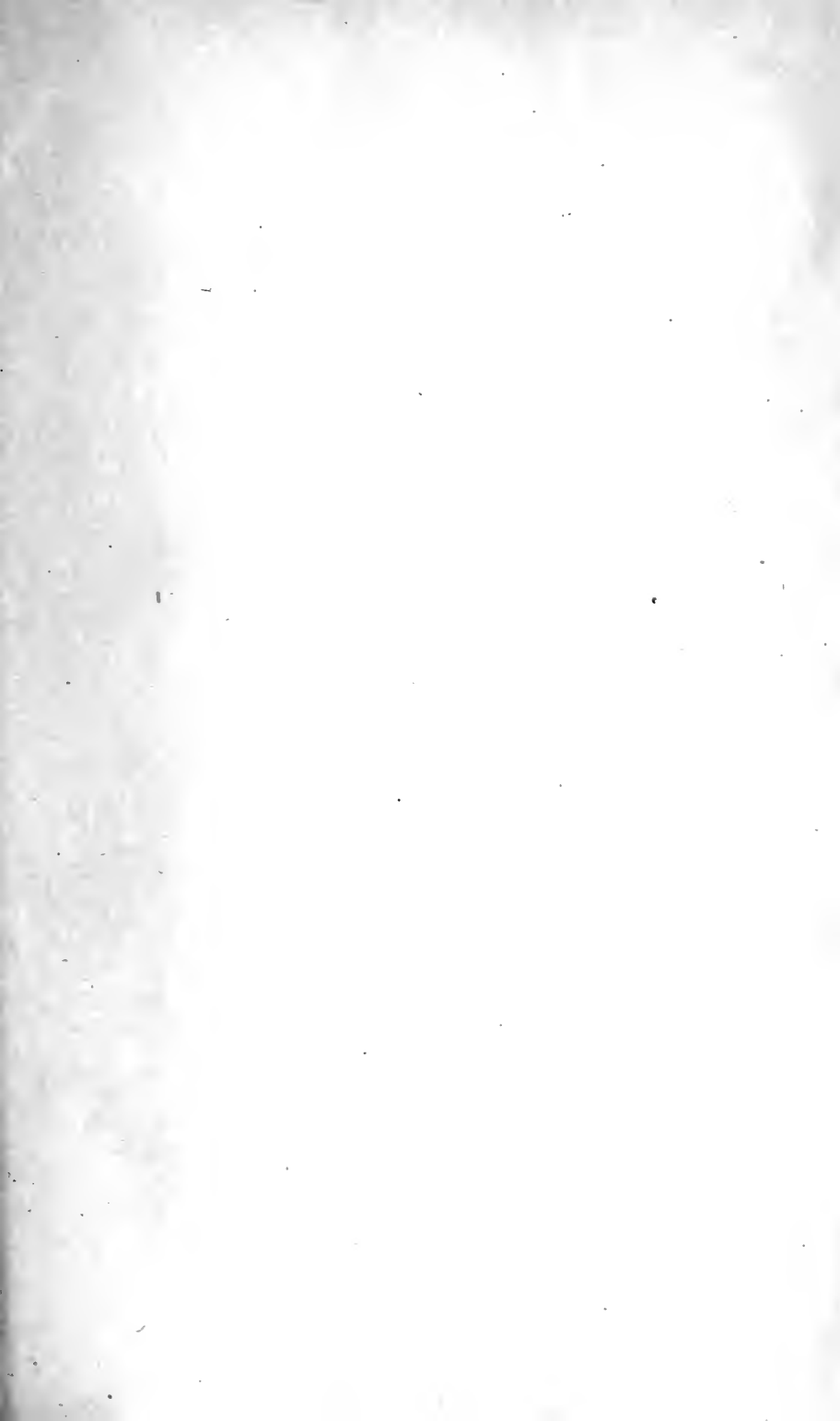
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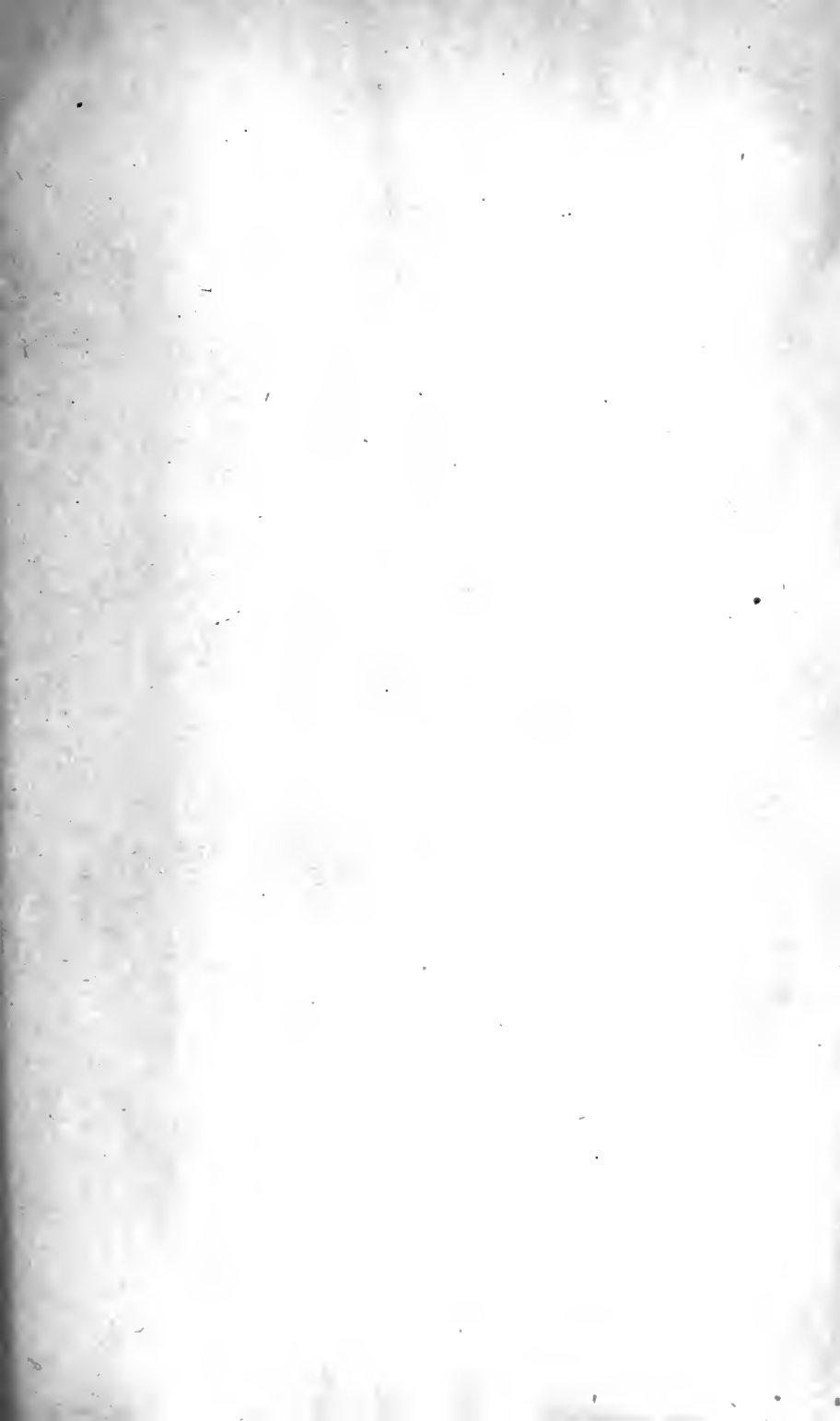
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